SKETCHES

OF THE

PHYSIOLOGY OF VEGETABLE LIFE.

Ellerton & Henderson, Printers, Johnson's Court, Fleet Street, London.

SKETCHES

OF THE

PHYSIOLOGY

OF

VEGETABLE LIFE.

BY THE

AUTHORESS OF "BOTANICAL DIALOGUES."

(Mrs. Maria E. Jackson)

What things soe'er are to an end referr'd,
And in their motions still that end regard,
Always the fitness of the means respect—
These as conducive choose, and those reject—
Must by a judgment foreign and unknown
Be guided to their end, or by their own.

BLACKMORE'S *Creation.*

LONDON:

FOR JOHN HATCHARD, BOOKSELLER TO HER MAJESTY,
190, OPPOSITE ALBANY, PICCADILLY.

1811.

This small volume is submitted to the Public by the Authoress of Botanical Dialogues, with the intent rather to excite and to direct, than to satisfy inquiry; and she entertains the flattering expectation, that, by laying before the youthful student of Botany a variety of curious and extraordinary facts in the habits and properties of Vegetable Life, she may be the means of extending the present prevailing taste for the nomenclature and classification of Plants to the more useful and interesting part of the science, the Physiology of Vegetation.

CONTENTS.

EXPLANATION

OF THE

PLATES.

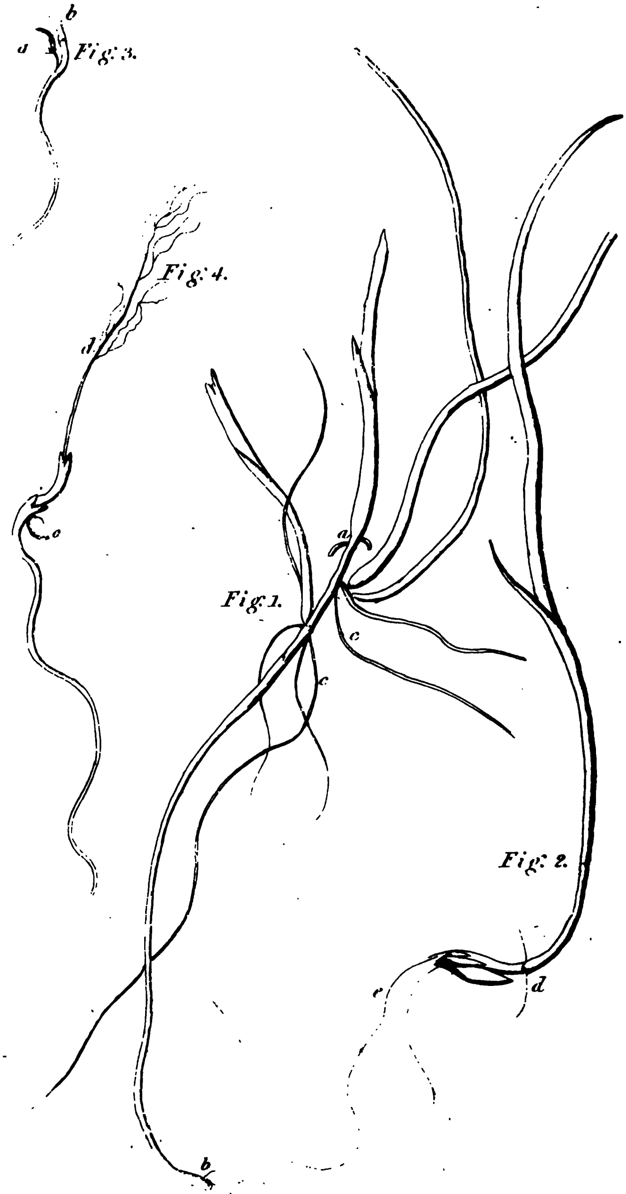


Fig: 3.
a
b
Fig: 4.
d
c
Fig: 1.
a
c
c
Fig: 2.
d
e
b

PLATE I.

(Referred to at page 152.)

Fig. 1. A plant of common Oat, taken out of a manured border, to shew the very long tubular cord by which the coronal-roots are separated from the seed-roots. And to shew also the bud-roots from various points; *a*, coronal-roots; *b*, seed-roots; *c*, *c*, roots protruded from the buds formed at the points of the stem.

Fig. 2. A plant of Oat, to shew the very short tubular cord betwixt the coronal and the seminal roots; *d*, coronal, *e*, seminal. This difference might probably arise from the greater or less depth of earth into which the seeds were planted.

Fig. 3. A young plant of Asparagus, sowed in March, taken out of the ground May 30th; *a*, the seed, firm and full; *b*, the bud.

Fig. 4. An Asparagus plant, of the same period of growth; *c*, the seed, shrivelled, the outer coat only remaining; *a*, the bud, fully expanded.

Plate 2.

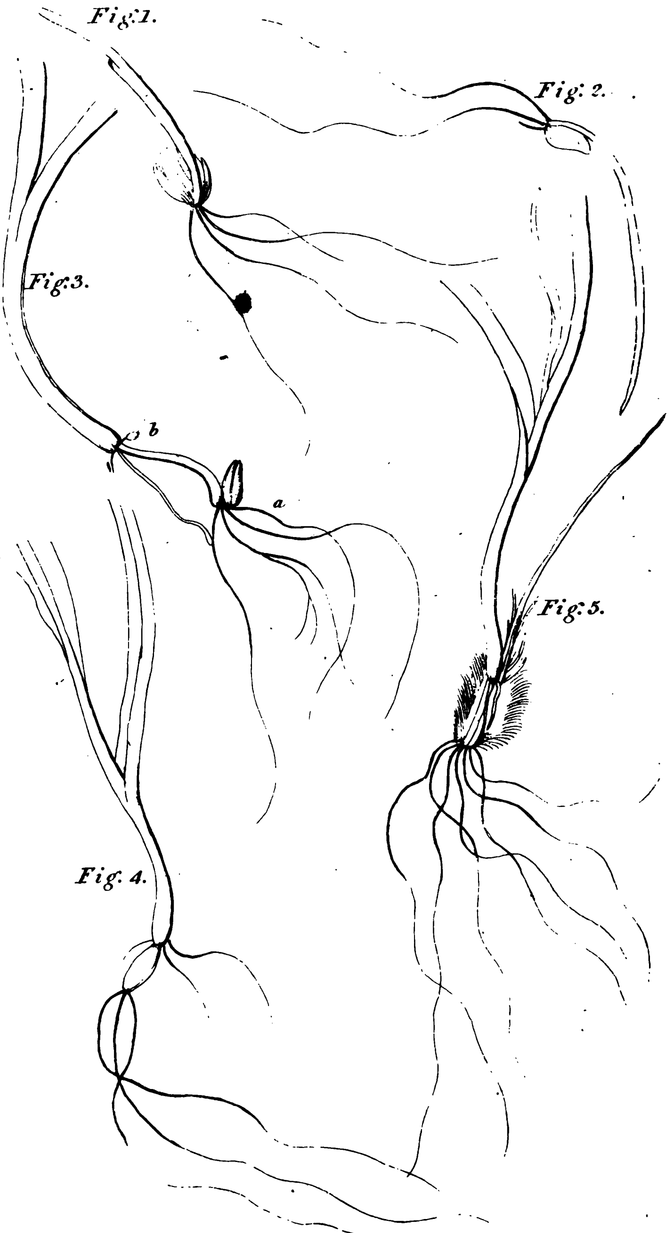


PLATE II.

(Referred to at page 152.)

Fig. 1. A plant of common Oat; the outer husk of the cotyledon opened to display the manner of the germ shooting from the inner part.

Fig. 2. A plant of Wheat, at the same period of growth, shews the germ shooting from the outside of the cotyledon.

Fig. 3. A plant of Wheat, to shew the seminal and coronal roots; *a*, seminal; *b*, coronal.

Fig. 4. The same in a plant of common Oat.

Fig. 5. A plant of Avéna Fátua, to shew the seminal and coronal fibres.

Plate 3.

Fig. 1.

Fig. 3.

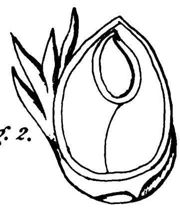


Fig. 2.

Fig. 4.

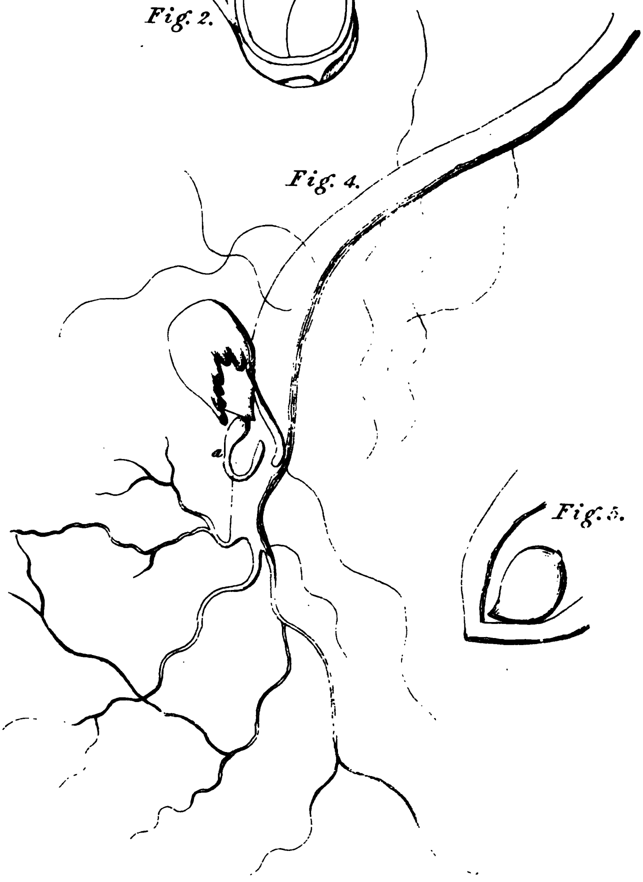


Fig. 5.

PLATE III.

(Referred to at page 152.)

Fig. 1. A common Nut, August 4th, opened, to shew the minuteness of the kernel, or cotyledons, and its adhesion, by the narrow end, to a cord, by which it is connected with the pithy substance which lines the shell. The kernel in a state of mucilage.

Fig. 2. A common garden Nut: to shew the increased size of the kernel from August 4th to August 18th, the line round the kernel, and the line down the middle of the shell, are formed of a dark pithy substance, uniting the kernel to the base of the shell; this cord and pithy substance adhere only to the skin of the kernel.

Fig. 3. October 2d. A nut kernel at full growth.

Fig. 4. A plant of Filbert, to shew the manner of germination, *a*; taken out of the ground at fifteen months growth; the shell dropped; the kernel apparently plump and fresh: when examined, found to be wrinkled and dried.

Fig. 5. An Apricot kernel, to shew the adherence of the kernel to the shell by a small part of the skin.

Plate 4.

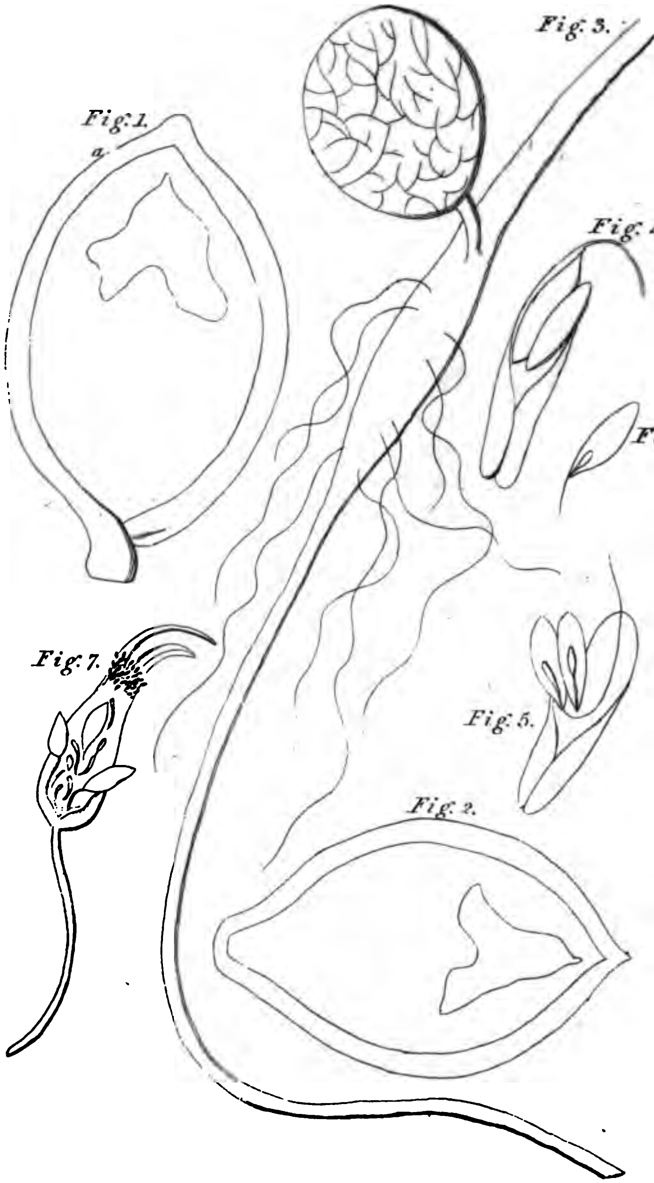


PLATE IV.

(Referred to at page 152.)

Fig. 1. One side of a Walnut, to shew the cotyledons, or kernel, lying within the pithy lining of the shell, slightly attached to it by the outer skin.

Fig. 2. The other side of the same, to shew the germ within the cotyledons: the cotyledons in a state of mucilage.

Fig. 3. A Walnut plant, sowed in spring, taken out of the ground in July; shews the manner of germination: the kernel firm, and sweetish to the taste.

Fig. 4. A seed-vessel of an Ash tree, split, to shew the cord by which the seed is attached to the base of the seed-vessel.

Fig. 5. A seed-vessel of Ash; the seed-vessel opened, to shew the cotyledon containing the germ, split in two lobes; the plume and radicle of the germ divided.

Fig. 6. One side of the seed-lobes of Ash, containing the germ undivided.

Fig. 7. A berry of Alpine Rose; the seeds drawn out, to shew the manner in which they are attached to the pulpy seed-vessel by a thread, or bunch of vessels.

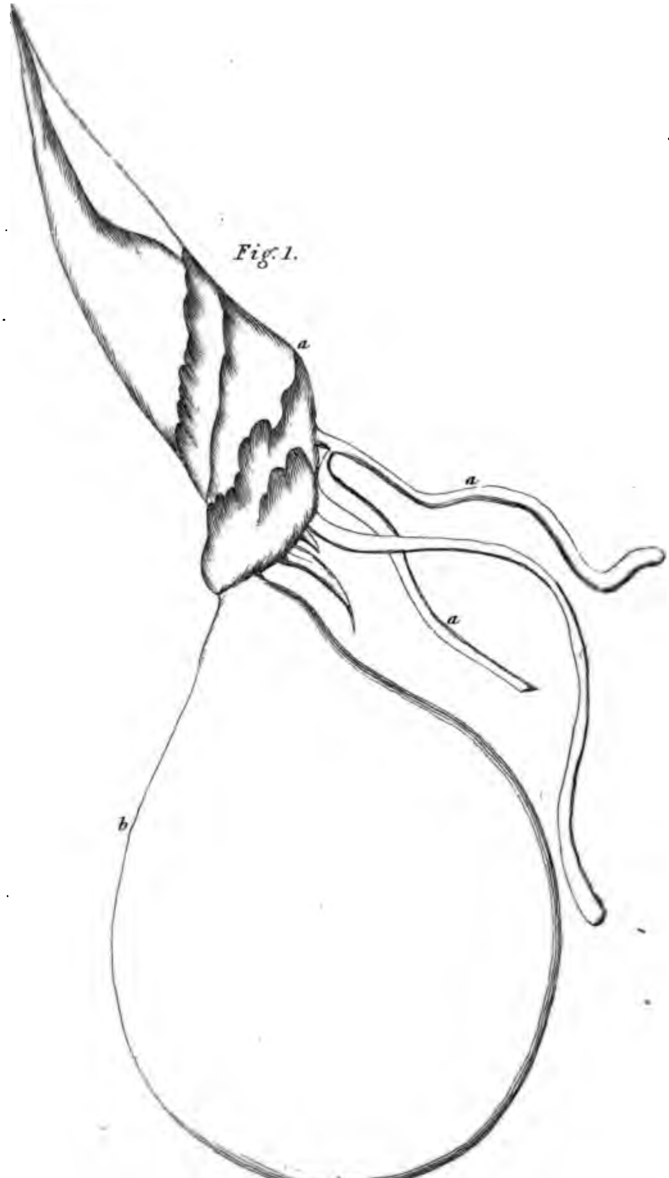


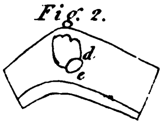
Fig. 1.

PLATE VI.

(*Referred to at page* 153.)

Fig. 1. The plume, with the radicles and ball, *a, a, a,* separated from the shell of the Cocoa-nut: the kernel, or cotyledon, which lined the shell, dry and not eatable; the pithy ball, *b,* soft to the touch, very spongy and oily; not any of the milky liquor, usually found within a Cocoa-nut, previous to an advanced state of germination, remained; the spongy ball nearly filled the shell. The kernel-like part, at the broad end of the shell, was very thin, and the colour of the brown coat of the kernel visible through it.

Fig. 2.



4

Fig. 3.

Fig. 1.

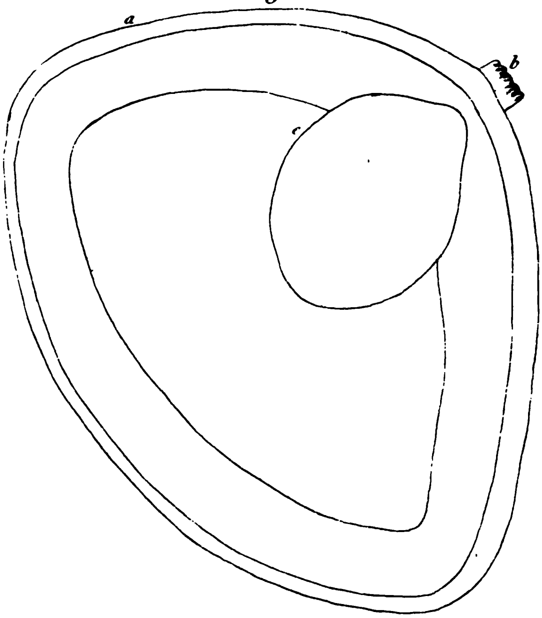


PLATE VII.

(*Referred to at page* 153.)

Fig. 1. A Cocoa-nut, opened, to shew an appearance which is not to be seen before germination has taken place. The black rim, *a*, marks the shell, the second line the thickness of the kernel, or cotyledon; *b*, supposed the rudiment of the plume, the upper part of which had been broken off; *c*, the pithy ball. The nut was full of milky liquor; the kernel perfectly juicy. By nicely cutting away the kernel part, the communication of the ball, and the supposed rudiment of the plume, was plainly visible. The ball, in the state of growth represented at Fig. 1, was as hard and juicy, as the kernel of a common nut fully grown.

Fig. 2. A small piece of the kernel-like lining of a Cocoa-nut, which, externally, had no appearance of germination, except a small rise of the kernel through one of the holes of the shell. When carefully sliced, the germ, *d*, was found lying in a small cavity of the kernel, or cotyledon, with the rudiment of the pithy ball, *e*, to which it was attached.

Fig. 3. The outside of the whole of the germ, taken out of the cavity within which it was lodged. No apparent communication betwixt the germ with its ball and the cotyledon, or kernel part of the nut: no distinct appearance of leaves in the germ; the two parts marked . ., sweet to the taste; the upper part bitter.

Fig. 4. The same as No. 3, split in two parts.

N.B. The radicle of the germ of Cucumber is sweetish to the taste; the plume very bitter.

Plat

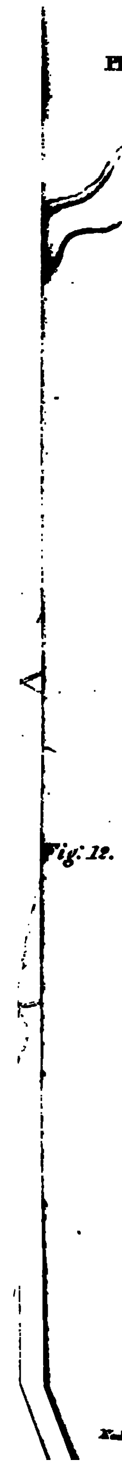


Fig: 12.

PLATE VIII.

(Referred to at page 158.)

Fig. 1. A small scaly bulb of Orange Lily, to shew the radicles from the joints of the stem, *a*, *a*.

Fig. 2. The same; the outer scales taken off, to shew the new forming bulb, *c*.

Fig. 3. A leaf-bulb of Fiery Lily.

Fig. 4. The same opened, to shew the new bulb, *a*.

Fig. 5. A leaf-bulb, of older growth, of Fiery Lily, to shew the stem bulbs, *a*, *a*.

Fig. 6. The same; *b*, the new bulb.

Fig. 7. A bulb of Hare-bell.

Fig. 8. The same; the outer coat scraped off, to shew the new bulb, *a*.

Fig. 9. A bulb of Fritillária Meleágris. *a*, shews the state of the seed-vessel when taken out of the ground.

Fig. 10. The same bulb opened; *b*, the new bulb.

Fig. 11. A leaf-bulb of Fritillária Imperiális.

Fig. 12. The new bulb.

Fig. 13. A Hyacinth bulb, the outer coats cut from the caudex, or base, from whence they sprang. *a*, the new bulb; *b*, the old stem of the flower. The leaves were beginning to decay at the time the bulb was taken out of the ground; the flower-stem quite decayed.

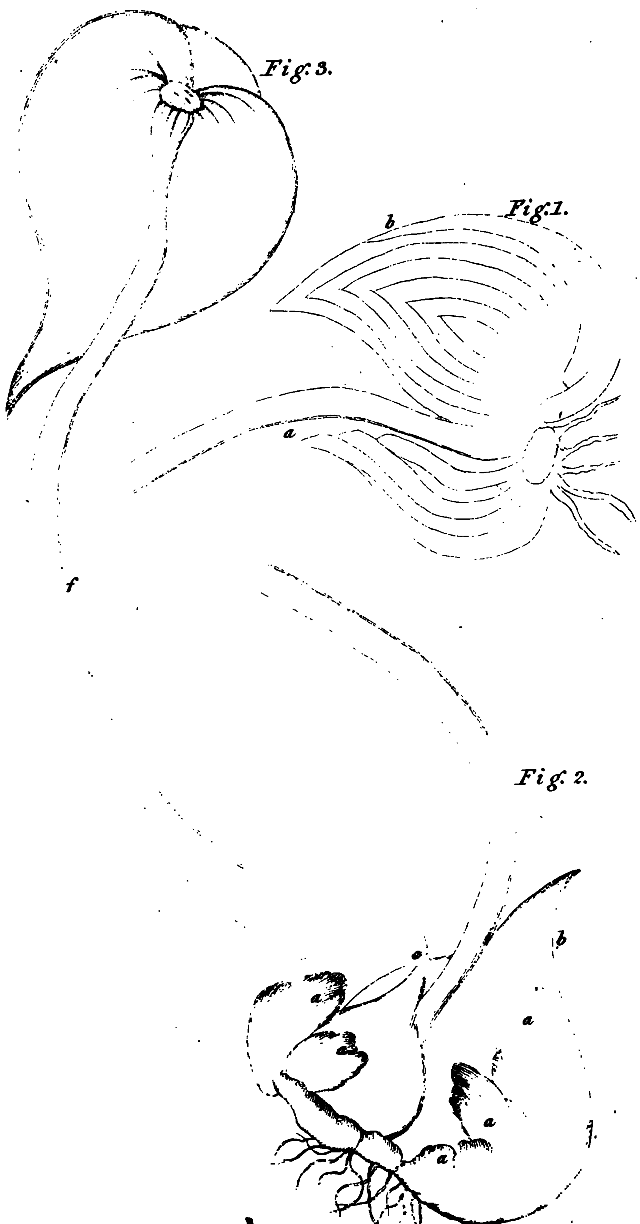


Fig. 3.
Fig. 1.
b
a
f
Fig. 2.
b
a
a
a
a
a

PLATE IX.

(Referred to at page 158.)

Fig. 1. A Tulip bulb, split, to shew the position of the flower-stem within the coats of the bulb of the preceding year, *a*, and the newly-formed bulb on the side of the flower-stem, *b*.

Fig. 2. A Tulip root, taken out of the ground July 6; the stem and leaves entirely withered; not any thing remaining of the old bulb, except a few dry husks, *a*. *b*, the new bulb; *c*, a smaller newly-formed bulb sticking amongst the dry husks.

Fig. 3. The larger bulb, the outer skin taken off, *f*, the stem of the flower of the preceding year.

Plate 10.

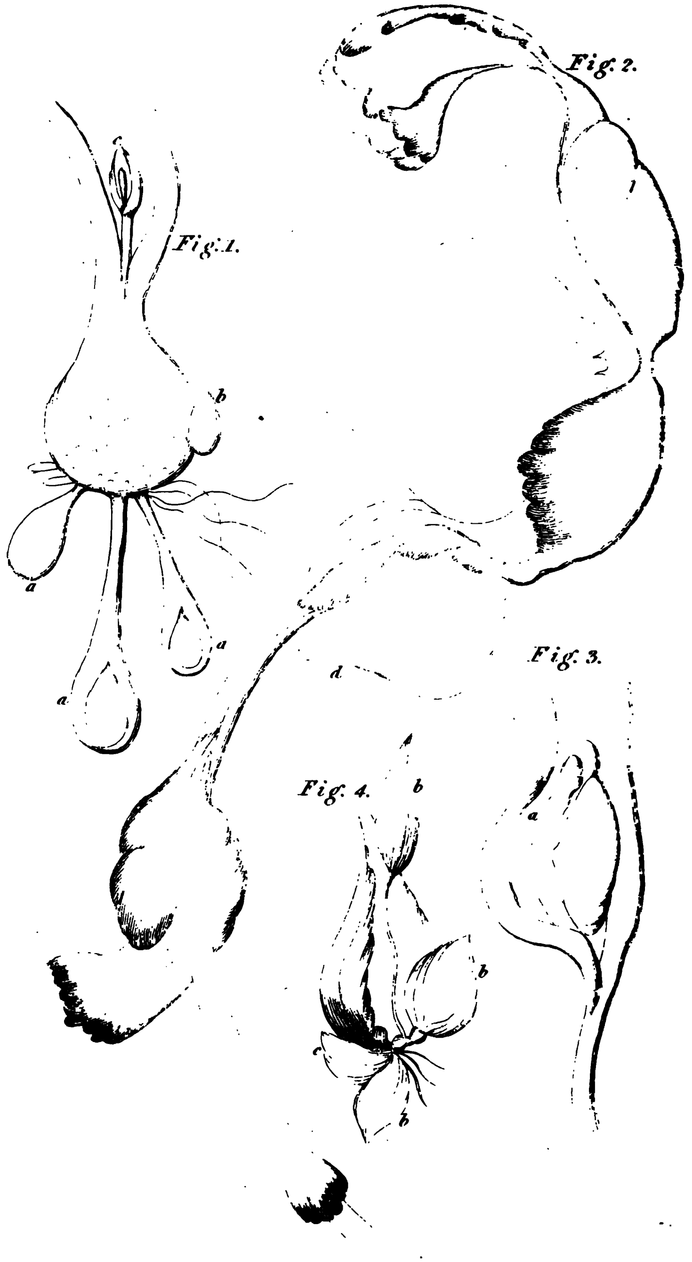


PLATE X.

(Referred to at page 159.)

Fig. 1. A bulb of Tulip, taken from a glass of water, wherein it had put forth the processes, *a*, *a*, *a*, and the small bulb *b*. *c*, the flower, decayed; not any large bulb formed; the old root decayed.

Fig. 2. A Tulip root, with the stem, to shew the bulb formed on the flower stem, *d*, and the unusual form of the leaves.

Fig. 3. Another stem-bulb of Tulip, *a*.

Fig. 4. A root of Iris Xiphium, to shew the extraordinary product of bulbs. *b*, *b*, *b*, *b*, new bulbs.

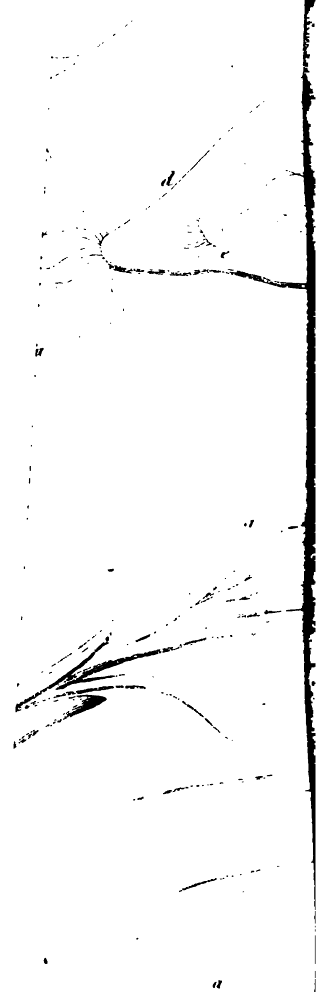


PLATE XI.

(*Referred to at page* 160.)

Fig. 1. A Colchicum bulb, taken out of the ground September 26, 1793; apparently only a single bulb. *a, a, a,* flowers.

Fig. 2. The same, stripped of the brown husk; *a, a,* fibres belonging to the bulb from which the two flowers, *b, b,* grow; *c,* a bulb on the opposite side of the large bulb, bearing only one flower; *d,* the large bulb of the preceding year; *e,* the decayed remainder of the root-fibres; *f,* the decayed remainder of the leaves.

Fig. 3. Two Colchicum bulbs. October 1, taken from the large bulb of the preceding year, *A*; stripped of the husks and films; the flower, the green leaves, and the rudiment of the new bulb remaining; *a,* the flower, with its tube; *b, b,* the tender green leaves; *c, c,* the rudiment of the new bulb, with its fibres.

Fig. 4. The same, the flower taken off, to shew the situation of the seed-vessels in the bosom of the young green leaves, *a.*

Fig. 5. August 24. To shew the state of the new bulb, *a,* at that period.

Fig. 6. A Colchicum bulb, taken up in May. *a, a,* bulbs formed the preceding autumn; *b,* the withered remains of the old bulb. The leaves of the new bulbs were at their full growth, not any seed-vessels within them.

Plate

PLATE XII.

(Referred to at pages 161—163.)

Fig. 1. A bulb of Crocus, May 24th. *a*, the new bulb; *b*, the old bulb, nearly absorbed.

Fig. 2. Bulb of Crocus; . . flowers for the ensuing year, with the rudiments of new bulbs.

Fig. 3. Crocus bulb, November, to shew the state of the flowers, *a*, *a*, *a*; new bulb, *c*.

Fig. 4, 5. Seedling plants of Crocus; sowed, autumn 1791; taken out of the ground, March 1792. At Fig. 4, . shews the seed remaining to the plant firm and juicy; *a*, at Fig. 5, shews the small new bulb at the base of the leaf, on the summit of the old bulb, the sheath being taken off.

Fig. 6, 7. Crocus bulbs of the second year's growth. Fig. 7, at *a*, a long process from the bulb; *b*, an offset.

Fig. 8. Crocus bulb of the second year's growth.

Fig. 9. Crocus bulbs of extraordinary forms.

Fig. 10. Two new bulbs formed from a Crocus bulb; *a*, the remainder of the old bulb.

Fig. 11. A bulb of Erythrónium (Dog-tooth Violet), December 1790. *a*, the remainder of the bulb of 1789; the greater part of which had been absorbed by the new bulb, *b*; *c*, the green bud, containing the flower; *d*, an offset.

Fig. 12. The flower taken out of a bulb of Erythrónium, to shew the rudiment of a new bulb, *a*.

Fig. 13. An old bulb of Gladiólus Commúnis; *a*, a new bulb; *b*, a long process from the old bulb; . an offset.

Fig. 14. An extraordinary production of the bulb of Gladiólus.

Fig. 15. Orchis Mório, taken from an engraving, to shew the two bulbs, *a*, *a*.

Fig. 16. A plant of Monorchis, taken from an engraving, to shew the newly-formed bulb, *a*, resembling the manner of growth of bulbs of Potatoe; *b*, the old bulb.

e 15.

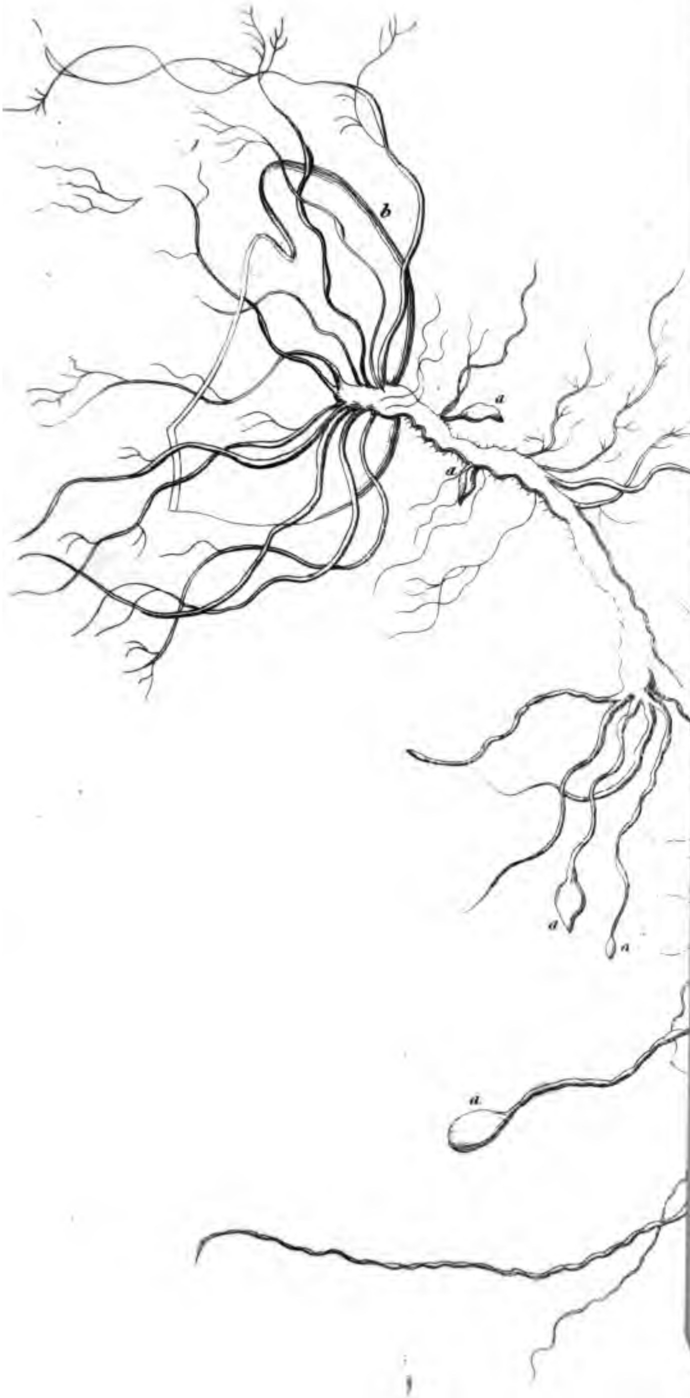


PLATE XIII.

(Referred to at page 165.)

Fig. 1. A plant of Potatoe, to shew the young bulbs, or Potatoes, formed at the end of the fibrils, *a, a, a, a, a, a*. *b*, the piece of Potatoe from which the branch was put forth.

Plate 1

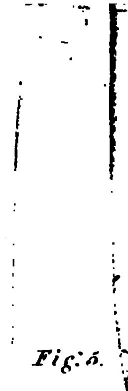


Fig: 6.

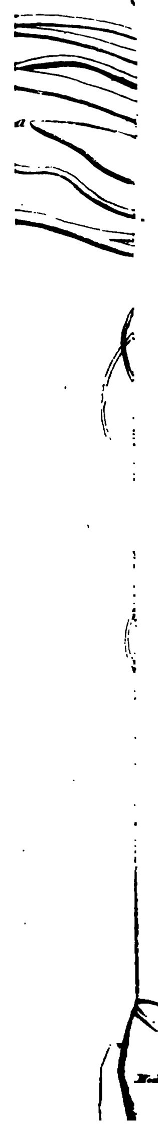


PLATE XIV.

Fig. 1. A bud of Aconítum (Blue and White Monk's-hood); *a*, an old stem, with the withered bud of the preceding year; *b*, the part by which the new bud is attached to the old one; *c*, the new bud, with many fibres.

Fig. 2. The new bud cut open; the outside of the bud shewn; *a*, the leaves folded in the bud.

Fig. 3. An open outer-leaf, taken from the young bud.

Fig. 4. An inner leaf of the same bud.

Fig. 5. A bud of European Tróllius. *a*, the new bud, in the midst of old decayed leaves, adhering to the part analogous to the caudex of bulbs, *b*.

Fig. 6. The bud cut open, to shew the embryon flower, *a*.

Fig. 7. A bud of Chelone, expanded; *a, a, a, a, a, a*, shew the new bud and its fibres; *b*, a new forming bud, with the summit broken off; *c*, the root-fibres; *d*, the old decaying stem, with two root-fibres.

Fig. 8. A new bud of Chrysocóma, *a, a*, with small buds at the base.

Fig. 9. A new bud of Chrysocóma, *a*, with the old stem, *b*.

PHYSIOLOGY

OF

VEGETABLE LIFE.

THE taste for botany which has of late years so generally prevailed amongst all ranks and ages of society, and more peculiarly manifested itself in the younger part of the female sex, has long rendered me desirous to attempt to lead the more inquiring minds of those engaged in this interesting and rational pursuit, to a deeper investigation of the habits and properties of that division of organized nature denominated the vegetable kingdom, than is usually entered into by students of the technical part of the science. Hitherto, however, research into the economy of vegetation has been

too limited to admit of the result being formed into a regular elementary treatise; and the few books from which information might have been obtained, too philosophical, and too voluminous, to amuse the leisure hour of youthful students. These impediments no longer remain; and we have now various treatises on the physiology of the vegetable creation, which, with the book of nature open before us, will render the comprehension of this most interesting part of the science by no means difficult.

To Dr. Benjamin Barton, an American, we are indebted for the first English elementary treatise, which, with an extensive delineation of systematical botany, has combined a succinct view of the physiology of vegetation; mingling with the whole a variety of curious fact and observation, from which the young student may derive a considerable portion of instruction and amusement. We have translations of Professor Willedenow's Principles of Vegetable Philosophy, of

parts of M. Mirbel's "Traité d'Anatomie et de Physiologie Vegetales;" and, above all, the highly respected President of the Linnean Society has given us an Introduction to Physiological and Systematical Botany, comprising a compendium of the various opinions of the most able philosophers in the science of vegetation, and of facts the most worthy to excite our attention; added to which, we find that liberal observation, and candid remark, which ought ever to accompany true knowledge, and which peculiarly distinguish the writings of Dr. Smith. An attentive perusal of these books, with a comparative view of the subjects on which they treat, will afford the student competent information of those parts and properties of vegetables from which he can alone expect to obtain the knowledge of their natural history;—a wide field of research and speculation, open equally to the learned and unlearned inquirer.

Although it is from Barton, Willedenow, and Smith, only, that we have com-

plete elementary treatises, there are various authors from whose works much important information and entertainment may be received. Dr. Nehemiah Grew, the first English philosophic writer on vegetation, details, in his Anatomy of Plants, a variety of important and interesting observations: the Vegetable Staticks of Dr. Hales, the writings of the ingenious Professor Bradley, afford us much acute remark and valuable opinion: from papers of the French Institute, from various detached papers which may be found in different periodical publications, much curious matter may be collected: M. Bonnet on the Use of Leaves in Plants, Duhamel's References, La Physique des Arbres, lay before us numerous interesting and well-executed experiments. Nor must I omit the works of the late celebrated philosopher, and much-lamented member of society, Dr. Darwin, on the subject of vegetable physiology: and although, as being derived more from speculative inquiry than from actual ex-

periment, his theories ought to be received with caution, the young student will not act wisely if he be deterred from giving due weight to the ingenuity of his conjectures by the alarm he may receive at the boldness of them. And here I cannot but lament not having it in my power to direct my inquiring pupil to the papers of the ingenious Mr. Andrew Knight, on the interesting subject of the ascent and descent of the sap in trees, and various observations equally worthy to engage the attention, except as scattered fragments in the Philosophical Transactions, or in different periodical publications. These papers must be esteemed of the first consequence to the student of vegetable philosophy; their author having accompanied theory with experiment throughout the whole of his researches: and as, from the ingenuity of his abilities, and the advantage of uninterrupted leisure, enjoyed from his situation in life, he seems peculiarly fitted for inquiry into this intricate and amusing

branch of natural history, we may be allowed to hope he will soon give to the world these valuable papers collected into a whole; thereby rendering them more generally useful than while they remain in their present dispersed state they can, comparatively, be found.

As now, therefore, the botanical student is no longer destitute of books by which he may guide and direct his researches in the physiological part of the science, I am desirous, by laying before him a short sketch of the most remarkable phenomena in the history of vegetable life, to stimulate his curiosity, and to excite his emulation, to enter himself on the list of those ingenious inquirers whose experiments tend to the elucidation of that interesting point of doubt, "Whether vegetables are possessed of faculties which may entitle them to a place amongst the animal orders of the creation?" Facts and analogy must combine their evidence to establish their claim to animal nature: nor can a pupil of the school of Linneus

have made any proficiency in the botanical system of that great master, and remain wholly ignorant of the philosophical part of the science: neither can the intelligent student have exercised that nice and discriminating investigation of the various parts of fructification, which is necessary to the distinction of the respective genera, without having experienced some desire of acquiring more extended information respecting the habits and dispositions of plants, than the limited study of their classification could supply, and which, by an inquiring mind, can be esteemed an introductory step only to the knowledge of the vegetable creation.

The great progress which has lately been made in the discoveries and improvements of vegetable physiology has laid before us almost innumerable experiments, ingeniously planned and accurately executed, all tending to elucidate the habits and structure of vegetable nature; a subject so intricate, and difficult to

investigate, that there are few points wherein the strictest researches of the most able naturalists have yet proceeded far beyond conjecture. The young student should not, however, be deterred, by the difficulty of arriving at decided information, from the pursuit of a subject wherein his labours will meet their reward by the beauty, delicacy, and variety of structure in each individual of the vegetable kingdom, which a nearer research into the economy of their nature will present to his view. And although the abilities belong to few which can enable mankind to look into the heights and depths of this world of wonders, there may be found, in all parts of both the vegetable and animal creation matter, sufficiently obvious to the eye of the common observer, to engage the mind and usefully occupy the time of the young physiologist; and if he bear in mind that actual observation and accurate record must furnish instruction wherever they may be found, he cannot want a stimulus to

the indulgence of his taste for the beauties of nature, in a systematic investigation of the modes and structure of the various interesting objects which in every path solicit his attention; and while he may learn the useful lesson of humility, by the difficulty he finds in acquiring an accurate knowledge of even the most simple work of our great Creator, he may be encouraged to proceed by the reflection, that it is from an accumulation of well-conducted experiments, and facts accurately stated, that any just theory of vegetable life can be deducted. If, therefore, he can add, to the general stock of knowledge on this interesting subject, the peculiarities and habits of one genus only, his time in the research of the secrets of this beautiful part of nature will not have been idly employed. Limited and erring as are the human faculties, we cannot but be sensible that we are indebted to the wise exertion of them, not only for the comfort and accommodations of refined life, but even for the necessaries

essential to our existence; and when we take a view of the very slow degree by which the highest of the arts and sciences have attained perfection, we shall not be discouraged by the little we may be able to effect, from attempting those discoveries which may be within our power.

However philosophers may differ in respect to the final cause of the various beautiful phenomena exhibited by the vegetable creation, no one can doubt of facts which may be made obvious to the eye of every attentive observer; the living principle of vegetables being scarcely more easily perceptible than that variety of spontaneous movement which renders their subject so peculiarly interesting; and, although these movements are yet generally attributed to the effects alone of irritability, may we not venture to hesitate in giving our assent to this opinion, until further observation shall have more fully established the fact? Nor can we contemplate the subject without being

led to the belief, that those movements of vegetable life, so well directed as a mean to the attainment of an end, must proceed from a superior cause to that alone by which inanimate matter may be excited into motion. Be this, however, as it may, it is certain that the deficiency of sensation in plants has not yet been ascertained; and we must recollect, that the existence of the sensitive faculty in vegetable life, has been acknowledged and maintained by naturalists of distinguished abilities.

While, therefore, we are withheld, by this contrariety of opinion, from submitting our judgments to the authority of even the most respectable writers, we must learn to doubt the apparent result of our own researches, and carefully divest ourselves of partiality to either system in the examination and experiments of the facts which present themselves to our consideration. By an attentive observation of the motions of vegetable life, we discover in plants an appearance of volition equal to that which manifests itself

in various tribes of the animal creation. The astonishing mixture of animal and vegetable nature throughout the tribe of zoophyta, seems to lay a foundation of analogy betwixt the two kingdoms not very easily to be shaken. In the lower orders of zoology there exists a wonderful tribe of beings, so distinct from the common appearance of animal life, that they seem almost equally allied to the vegetable creation. Among these extraordinary productions of nature, the Actiniæ form a genus of the most beautiful and curious kind; and one of the species, frequently found on the shores of this country, so nearly resembles the Double Anemone in its appearance, as to have familiarly obtained the name of that flower. This curious animal structure adheres so strongly to the rocks, as often to be left, at the ebbing of the sea, above the water, although it is generally found below its surface. When separated from its native rock, it becomes languid, like a plant deprived of the earth wherein

it grew, and still further preserves the analogy to vegetable existence by the capability of being divided into several parts, each of which becomes a complete animal: the manner, however, in which the division is made, must, as in vegetables, be attended to. The Actiniæ also resemble plants, by preserving life when kept in vessels of sea water, and producing, in that confined state, a numerous offspring, although they make no progress in growth; a circumstance similar to bulbous roots placed in water, which retain strength sufficient to enable them to throw out young bulbs, but lose the power of re-producing a vigorous flowering bulb, as when they are supplied with the more nutritious juices of the earth. The Sertularia is a genus of the zoophyte class, so remarkable for its vegetable appearance, as to be commonly esteemed a kind of sea-moss. The Sertularia Pinnata, one of the most elegant species of this curious production of nature, and the most simple in structure, is frequently found adhering to oysters and

other shell-fish, and could never, by a casual observer, be supposed of animal nature: and, indeed, so late as the beginning of the eighteenth century, it was the opinion of some ingenious naturalists, that several species of zoophytes were of vegetable origin; nor was it till within the last seventy or eighty years, that the fact of their belonging to the animal order of the creation was fully established.

The deficiency of a brain in the vegetable structure, has been esteemed a decisive mark of distinction between the plant and the animal; but this line of separation is set aside by an attention to the lower orders of animal life, the most accurate research not having yet discovered in the Polypus either brain, nerves, or muscles. The polypus preserves its analogy to vegetable life in a variety of circumstances; and in not being an animal difficult to obtain, and whose habits are easy to be observed, forms the best object of comparison between the two

kingdoms that can be presented to the young student. But it is not in the polypus alone we find that deficiency of organs, which has been supposed to form the line of distinction between the animal and vegetable creation. Dr. Hooper* is said to have proved, that nothing like nerves can be found in the system of Intestinal Worms. Yet no one doubts of these beings having the faculty of sensation. In the papers of the Linnean Transactions, vol. ii., we have an account of the Tænia (tape-worm); wherein we find, that in the animals of this genus, not any thing resembling a brain or nerves has been discovered, nor yet any particular organs of sense, the sense of touch being the only evident source of intelligence which they possess; and herein we perceive a still closer analogy to vegetable life than that which we observe in the polype species. The internal temperature of vegetables is also a

* Medical Review, vol. iv. Dr. Hooper on the Anatomy of Human Intestinal Worms.

strong connecting link between their nature and that of the animal tribe. The late celebrated Mr. John Hunter, by applying thermometers to the internal parts of vegetables newly opened, discovered that they possessed, in frosty seasons, a degree of heat above that of the atmosphere, although inferior to the warmth of cold-blooded animals; and we are in possession of experiments by C. Salome *, from which it appears that vegetable life acts, in regard to internal heat, in a similar way with the animal organization. M. Willedenow † seems to esteem sensibility to the effects of Galvanism a circumstance which would afford some degree of proof that plants possess the faculty of sensation; and relates M. Humboldt's experiments upon four different species without success: on a fifth, however, he succeeded by a peculiar mode of management; "but," adds M. Willedenow, "how easy is it in such ex-

* Medical Review, vol. viii. 1801.

† Willedenow's Principles of Botany, page 229.

periments to be deceived!"—an observation which should be borne in mind by every vegetable physiologist, respecting all appearances, either in favour or disfavour of whatever system he may be inclined to adopt. From further Galvanic experiments upon the vegetable structure by M. Giulio *, of Turin, Mimósa Púdica shewed a contrary result to that which it had exhibited under the conduct of M. Humboldt; Mimósa Sensitíva, Púdica, and Asperata, were excited to contraction by the Galvanic pile; neither Æschinómene Americána, nor the Hedysarum Gyrans, shewed any susceptibility to this influence. M. Giulio observed a considerable difference in the effects of Galvanic irritation on plants and animals: in the latter the contractions were immediate on the application being made; in plants they took place slowly, successively, and at considerable intervals. May we not, however, esteem the experiment incomplete, as M. Giulio has omitted to mention

* Medical Review, vol. ii.

the species of animals which were subjected to the effects of the Galvanic fluid, in comparison with the vegetables submitted to its influence, as probably there might not be found a more decided difference in the degree of quickness with which the Galvanic matter passes through the animal and vegetable structure, than would take place between the more or less animated orders of the animal creation? The effect of the electric fluid is similar, when administered to excess, in its power of destruction, both to animal and vegetable life; and, on the contrary, according to late experiments, electricity, carefully made use of, has been found salutary to the individuals of each kingdom. It is far from my intention to enter deeply into this intricate subject: it is sufficient to my purpose, to lay before the botanic student a sketch of those leading arguments by which it has been attempted to prove the existence or deficiency of the faculty of sensation in the vegetable world; thereby hoping to induce him to

enter upon this curious subject, making the book of nature his study, in preference to the theories of her most able commentators; at the same time to feel diffident of his own ability to read that book which physiologists of the first respectability have found so difficult to elucidate; but keeping that ever before him, he may reap the greatest advantage by comparing it with those authors who have preceded him in his research into the economy of vegetation.

In the agreeable and ingenious Introduction to Physiological and Systematical Botany, by Dr. Smith, the pupil may become acquainted with a summary of the most esteemed theories of vegetable life, and with a variety of curious facts and experiments, which render this publication an acquisition to the youthful botanist of the first importance. We are not yet possessed of M. Mirbel's Anatomy of Vegetables in the English language; such extracts as have been given in the periodical publications are ingenious and interesting; and we must not disguise

tribe having been long believed destitute of the power of progressive movement; and in comparing the structure of the muscle, or of most other of the bivalve shell-fish, with the organization of vegetable life, we do not discover in that order of animals any parts which can induce us to ascribe to them superior loco-motive faculty to that which the mechanism of vegetables may lead us to expect. The power of loco-motion in shell-fish has, however, been established beyond dispute, and the muscle is now known to perform its migrations by that solid fleshy protuberance, which, from its shape, has commonly received the appellation of a tongue. The oyster, which was believed to be destitute not only of progressive motion, but of every species of sensation, has been shewn to have the power of performing movements perfectly consonant to its wants, to the danger which it apprehends, and to the attacks of the enemies by which it may be assailed. The wonderful power of voli-

tion in these apparently inert animals, and with which we are made acquainted by the ingenious labours of the philosophical part of mankind, may be a stimulus to our endeavours after the discovery of a final cause, superior to that of irritability, for the curious and beautiful movements observable throughout the whole tribe of vegetable life. The motions of plants, by their roots, have attracted the attention of the most superficial observers of the vegetable kingdom; the surprising distance to which they extend their fibres has not escaped the notice of the common labourer; and the skilful endeavours of the most ingenious gardeners have proved ineffectual, when exerted to confine the roots of fruit trees to a soil uncongenial to their taste. The roots of some trees have been observed to follow the open mould, by descending perpendicularly, and rising again in the same manner, until they have reached the soil of which they were in pursuit: that object obtained, they have then thrown out innumerable fibres, or

mouths, to receive the nutriment procured by their own exertions.

Mr. Tull, a writer highly esteemed on the subject of agriculture, relates a fact, which passed under his own observation, of an instance of extraordinary locomotive faculty, and power of self-direction, in the roots of a plant of Cone Wheat, which equal, at least, the migrations of an oyster. These roots were seen to reach the mould at three feet distance, after having passed through a row of wheat the length of a foot from the spot wherein the plant grew. It is a well-known fact, that plants will send forth fresh roots, if, by culture, the soil in their vicinity is rendered more friable, and thus a fresh accession of food offered to them. But, amongst the various instances of the motions of the roots of plants, so evidently directed to some specific object of advantage, either to their growth or protection, there is not any one more curious than that related by Sir James Nasmith, in a letter addressed to Lord

Kames (Life of Lord Kames, No. 2, Appendix, page 40, A. D. 1773), in respect to a number of Willows growing at that time under his observation. These trees had been frequently cut over at about eight or ten feet from the ground; their trunks, about fifteen inches diameter, generally open on one side, and so much decayed, that scarcely any thing remained but the bark and a small quantity of blea, or alburnum; their tops were furnished with fine shoots round their edges, which shoots had put out roots in great number from the part where they were connected with the tree: these roots, running down, some on the outside of the old trunk, and some on the hollow inside, until they reached the ground, into which they penetrated; and until they had attained that point, made no attempt to put out lateral shoots or fibres. It is added, that the size of the roots by which this migration was performed, was generally about the thickness of a walking cane; and that, in their way down, they

clung so closely to the old stem, as to have impressed a groove, in which they lay.

The phenomenon of the well-known and uniform direction of the plume and radicle of a seed, has long excited the attention of philosophers, without having yet received satisfactory explanation: although a seed be placed in the most contrary situations, it will invariably recover that position which raises the plume into the air, and enables the radicle to descend into the earth. Various attempts have been made to account for these reverse motions: and it will be well to consult the different respectable authors who have endeavoured to develope this secret of nature. (See Dr. Darwin's Phytologia, 9. 3.; Barton's Elements of Botany, page 247; Willedenow's Principles of Vegetable Philosophy, page 252; Mr. Andrew Knight, Philosophical Transactions, 1806; Dr. Smith's Introduction to Physiological and Systematical Botany, page 93.) We do not, however,

find any of them disposed wholly to admit the power of self-direction as the primary cause of the undeviating rise of the plume, and equally pertinacious descent of the radicle; but may we not, in the diversity of ingenious opinion, be allowed to doubt whether the motions of a seed, which unerringly adapts its different parts to the elements peculiarly suited to their respective wants, can be explained by mechanical impulse? And while the effect of that power is found insufficient to account for motions so well directed to their end, may we not venture to ascribe them to the same cause by which animal life is guided,—to means best calculated for its nurture and preservation? Plants of all kinds will make the strongest efforts to escape from darkness and shade, and to procure the cheering influence of the sun; this they will effect by bending, turning, and even twisting their stems, until they have disposed them in the manner best suited to receive the benefit of his vivifying rays. Some of those

plants, which have voluble stems, ascend other plants in their search after light and air, spirally, east, south, west. This may be seen in Hop, Honey-suckle, and Black Bryony, while others, as Convolvolus and Kidney Bean, turn their spiral stems west, south, east. This curious difference of vegetables in the attainment of the same end, has attracted the attention of philosophers, without the proximate or final causes having yet been detected.—Other plants are furnished with tendrils, for the purpose of climbing; and the wonderful efforts made by these tendrils merit attentive observation. If the tendril meet with nothing to lay hold of in its first revolution, it makes another revolution; and thus continues to turn, until it wraps itself up like a cork-screw. If a pole be placed at a considerable distance from an unsupported vine, the branches of which are proceeding in a contrary direction from that of the pole, the vine, in a short time, will alter its course, and will not stop until it clings about the

pole. M. Willedenow, relating the curious fact of plants which are supported by tendrils, when distant from a wall or shrub, invariably sending out their tendrils towards that side on which support may be found, conjectures, that the diminished force of the current of air may have influence upon the motion of the tendrils; and adds, that this phenomenon can scarcely be explained in any other way.

Will it be too daring to predict, that the variety of wonderful phenomena, which hourly present themselves to our view in the study of vegetable economy, will in a short time universally be ascribed to the same power of volition which we unhesitatingly grant to animals of the most inert nature? The efforts made by plants to present the upper surface of their leaves to the light, a material apparently essential to their existence, form a curious and interesting subject of inquiry. From M. Bonnet's elegant work, on the Use of Leaves in Plants, much

amusing information may be derived. We find there a detail of ingenious and accurate experiments, made by himself, for the purpose of ascertaining the use of their different surfaces. Notwithstanding the most exact care taken to retain leaves in those forced positions which deprived their upper surfaces of the light, he uniformly found them vigorous in their endeavours to regain that direction which disposed them most effectually to receive the benefit of the sun's influence; and if these attempts failed, death generally ensued. As the upper surface of a leaf is formed to convey to the plant that advantage which so evidently is derived to all vegetables from light, so is the lower surface best adapted to the absorption of moisture; but this being only one of the many parts of a vegetable which is furnished with vessels for this purpose, we do not in general find any extraordinary pertinacity in the leaf to expose its under surface so as best to attain that end: this, however, may be effected by the artifi-

cial management of a plant, and furnishes another curious instance of apparently spontaneous movement. If a plant be kept for some time without sufficient moisture, and a vessel of water be then placed under its thirsty leaves, they will quickly bend downwards, and endeavour to apply their inferior surfaces to the water thus presented to them.

The eminent degree in which the Sensitive Plant (Mimósa Sensitîva), possesses the power of motion, has excited attention from the infant to the philosopher. The irritability of this elegant little plant is excessive; its leaves shrink from the slightest touch, and fold their upper surfaces closely together; on the approach of cold or moisture, they equally collapse, although not so closely as when attacked by external violence: their situation, after having suffered from too rude a touch, resembling that which takes place in their sleep, has been attributed by that late eminent medical philosopher, Dr. Darwin, to a numbness or paralysis con-

sequent of too violent irritation, similar to the fainting of animals from pain or fatigue. The sleep of the Sensitive Plant, or the collapse of its leaves in the absence of heat or light, is by no means peculiar to their delicate structure; the whole tribe of compound leaves, which belong to the class of papilionaceous flowers, exhibit the same curious phenomenon: they will vary their positions two or three times in a day, according to the state of the atmosphere; and will uniformly, on the approach of night, dispose themselves in that direction whereby they may be best secured from the injury of nocturnal dews. Various are the modes in which leaves fold themselves on the approach of darkness, cold, or moisture, or to preserve themselves from the rays of a too ardent sun; and some nice observers have remarked, that their manner of arrangement is uniformly found to be that which is best calculated to afford protection to the young stems, buds, flowers, or fruit. The leaves of Tamarind tree are said to

contract round the tender fruit, and thus guard it with assiduous care from the cold of the night. The Cassia, the Glycine, and many of the papilionaceous plants, contract their leaves in a similar manner, for the preservation of the more tender parts of the vegetable. Simple leaves are also possessed of muscles, which apparently they are enabled to move at pleasure, and invariably exert this faculty of motion to the protection of their progeny, the infant leaf-buds and flowers. The leaves of Chick-weed, Asclepias, &c. are disposed in opposite pairs, which, during the night, rise perpendicularly, and join so closely at the top, as to conceal their flowers; nor do they expand again, until the sun has dissipated the humidity of the atmosphere. The leaves of Œnothera, although horizontal, or even depending during the day, rise in the night, and infold their tender florets in their bosoms.

So many are the instances detailed of spontaneous direction, by all who have made observations upon the faculty of

motion in the leaves of plants, as to render it probable that, by farther research, this may be found an established attribute of vegetable life, although, from the slowness with which it is commonly exercised, there may be many plants wherein it has not hitherto excited attention; and the gentle gradation by which most of those movements of foliage, here enumerated, are performed, renders them scarcely perceptible, except to the eye of a skilful observer. The proximate cause of these movements seems to be the exposition of the various parts of the vegetable in the most advantageous manner to receive or repel the benefits or injuries to which they are obnoxious from the different states of the atmosphere. In the Hedysarum Gyrans, we find, however, an instance of motion, which has not hitherto been observed in any other kind of vegetable, and from which this species of Hedysarum has obtained the common appellation of Moving Plant. It is a native of the banks of the Ganges, and has been

known in England many years. We have various accounts of the habits of this extraordinary plant; and, as its movements have not yet been accounted for by any of the ingenious philosophers who have attended to this phenomenon, they will afford the young student a subject well worthy his endeavours to elucidate. The Hedysarum Gyrans has trifoliate leaves, the terminal leaves being much larger than the lateral ones: the smaller leaves, in the day time, are continually moving up and down, in a circular manner; which motion seems to be performed by the twisting of the fibres at the bottom of the peduncle; and while one leaf is rising, its associate is generally descending; the motion downwards being quicker and more irregular than the motion upwards, which is steady and uniform. The large terminal leaves are said not to move in the day time, unless stimulated by the rays of the sun, and to cease their action when by clouds the solar influence is intercepted. But the most extraordinary circumstance, in

the motions of this singular vegetable, is, that the larger leaves, which, through the day time, in cloudy seasons, do not exert their faculty of motion, have their movements increased during the period of night. These motions also take place when the leaves are perfectly asleep; and it is farther remarkable, that the leaves, in the height of erection, and during very warm and serene days, have been observed to exhibit a tremulous motion. If, from any obstacle, the motion of the leaves be retarded, upon that obstacle being withdrawn, the motion is resumed with increased vigour. Nor is this wonderful faculty destroyed by the separation of a branch from the main stem; the branch being placed in water, the same motions have been found to continue in the leaves twenty-four hours after it had been parted from the parent plant.

The Dionœa Muscipula (Venus's Fly-trap), a plant brought from the marshes of America, and the Drosera (Sun-dew), of our own country, exhibit, in the me-

chanism of their leaves, a most curious instance of the self-moving faculty, and power of defence against the depredations of insects. The jointed construction of the leaves of Dionœa, by which they are enabled to close, upon the first attack of insects, the spines with which their margins are beset, their extreme irritability, all bespeak a mechanism intended for some purpose of importance. Nor, apparently, is there less design in the structure of the beautiful foliage of the Drosera, or Sun-dew, an English plant, which adorns most of our heaths in spring, and whose habits are well worthy of further investigation. The leaves of Drosera are fringed round their margins, in a manner very unlike other vegetable productions, and the point of every thread, of this erect fringe, is crowned with a drop of pellucid mucilage; the upper surface of the leav es is also beset with hairs, containing a vis- cous juice; so that an insect ca nnot at- tempt to prey upon them with impunity. And, in addition to the pow er of destruc-

tion derived from this glutinous material, this elegant little plant possesses the faculty of directing its weapons to the best advantage against the attacks of its enemies. When an insect settles upon its leaves, it has been observed to bend them upward, and, by pointing all their globules of mucus to the centre, completely to have entangled the depredator. It has been conjectured, that the flies and other insects, thus caught, may, in their state of decay, generate air, from which the vegetable that entraps them may derive nutrition. This ingenious suggestion, whether well or ill founded, is worthy the attention of the intelligent young botanist, who cannot view the wonderful apparatus of a variety of plants, without being led to theorize respecting the use of such curious mechanism: and should he be induced to conjoin, with his investigation of vegetable life, a research into the history of the insect tribe, and their mutual dependence on each other, he might probably be able to proceed further in the elu-

cidation of the knowledge of these two interesting orders of creation, than any of his predecessors have done before him.

The structure of the leaves of the Sarracenia Purpurea, an American plant, according to the hypothesis above mentioned, seems intended to answer the twofold purpose of allurement and destruction: their hollow, pitcher-like form being adapted both to the reception and retention of the rain, and their margins being beset with inverted hairs; so that the insects which are attracted by the water contained within the hollow of the leaf are prevented making their escape, by the hairs with which its edges are surrounded.

A most extraordinary circumstance, related by Dr. Smith*, was observed by one of the gardeners in the Botanic Garden at Liverpool, respecting another species of the Sarracenia genus, the Sarracenia Adunca. An insect, supposed to be of the Sphex or Ichneumon kind, was seen to drag several large flies to this plant,

* Introduction to Botany, page 93.

and with some difficulty force them into the tubular part, of the leaf, which was half filled with water; and on examination, all the leaves were found crammed with dead or drowning flies. So much labour, exerted by this active insect, evinces some important end to be effected to itself or progeny, by the store of nutriment thus accumulated; but the advantage derived therefrom to the plant, cannot be esteemed equally evident. A further curious circumstance, in the construction of the leaves of the Sarracenia Adunca, is, that they are formed in a manner that nearly excludes the reception of water from the heavens; so that the liquid, which they contain, must probably be secreted by the base of each leaf. There however are different opinions respecting the source from whence this elegant little reservoir is supplied with water, and the subject requires further investigation. But the still more elaborate apparatus of the Nepenthe Distillatoria, for the purpose of containing water, admits of little doubt that it is from a secretion of the plant

that this fluid is produced, as the tube by which each leaf is terminated, has its mouth furnished with a complete cover, which opens only occasionally. We are acquainted with various plants, which contain water in hollows formed by their leaves, or different parts of their stems, as Dypsacus, or the Fuller's Thistle, of this country; and the Tillandsia, or Wild Pine, of the West Indies, is said to have every leaf terminated, near the stalk, with a hollow bucket, like Nepenthes, large enough to contain from half a pint to a quart of water. I have not met with any observations on the taste or consistency of the liquid thus deposited; but it seems generally to be esteemed pure water.

The motions of the different parts of the fructification of plants, will afford us yet stronger evidence of the faculty of sensation in vegetable nature, than that exhibited by their foliage. The opening and closing of the petals of a variety of flowers, at certain hours of the day, was observed by Linneus to take place with

such strict uniformity, as to induce him to term that regularity of movement the Horologe, or Watch, of Flora. The numerous plants from which this horologe is formed, are arranged by Linneus under three divisions: the first division he has distinguished by the term Meteoric flowers, including such as less accurately observe the hour of unfolding, but which expand sooner or later, according to the state of the atmosphere. Those flowers which open in the morning, and close before evening, every day, but whose hours of expansion and of closing are earlier or later as the length of the day increases or decreases, he has termed Tropical. To such plants as open at a certain and exact hour of the day, and close again at another determinate hour, through all parts of the year, he has given the appellation of Equinoctial. Amongst the Meteoric flowers, the Calendula Pluvialis (Cape Marygold), is supposed to indicate, with certainty, the approach of rain, if it does not unfold its petals at seven o'clock in

the morning. Leontodon-Taraxacum (Common Dandelion), a tropical flower, opens betwixt five and six, and closes between eight and nine. Anagallis Arvensis (Pimpernel), one of the equinoctial order, is so exact in its hours of expansion and closing, that in our own country it has obtained the name of Shepherd's Clock. Numerous are the plants which, in their petals, exhibit this kind of sensibility; and probably there may not be any in which it does not in some degree exist. This curious phenomenon has been denominated the sleep of plants; and that it does not solely depend on the presence or absence of heat or of light, may be seen by consulting Stillingfleet's Calendar of Flora, wherein the times at which plants expand and close their petals, are stated with much accuracy, and wherein it appears that their periods of sleep depend more on the hour of the day than on any other circumstance.

We have an account of some ingenious

experiments made by M. Decandolle *, for the purpose of ascertaining the influence of light on different vegetable phenomena, particularly on the sleep and watching of plants, which merit attentive consideration. These experiments were made at the Museum of Natural History, in two caves, having no other opening than the entrance. One of the caves was heated by means of a stove; the other was illuminated by lamps affixed to the walls, the light of which was computed to be equal to that afforded by fifty-four wax candles of an ordinary size. That the flowers of a great number of plants blow and close themselves pretty regularly at certain hours; that these periods are not the same in different species; and that the leaves, during the night, preserve a different position from that which they assume in the day, are facts which may be obvious to any attentive inquirer; and the investigation of the cause of these

* In the Medical Review, vol. viii.

extraordinary movements is a subject of high importance to the elucidation of the history of vegetable life.

The result of M. Decandolle's experiments was various: in some plants, by exposure to artificial light, the movements which usually take place in the petals and the foliage of plants were prevented, and their habits in that respect entirely changed; in others, little or no effect was produced by the same means. The flowers of Nightshade (the particular species is not mentioned), exposed to the continued light of lamps, opened at night rather sooner, and closed somewhat later, than their wonted hour. The same change of habit took place also when the flowers were immured in darkness. M. Decandolle ingeniously endeavoured to effect an entire change in their hour of sleep: with this view he lighted lamps, for three successive days, at eight o'clock in the evening, and extinguished them at six in the morning. The first evening the plants flowered at night, as usual; but the two

following days they flowered in the morning, and did not close again until the evening, at the instant that they were illuminated by the lamps; the direct reverse of their habits in the open air. The flowers of the Ornithogalum Umbellatum (Umbelled Star of Bethlehem), which in their natural situation of growth open every day about eleven o'clock, and close at three in the afternoon, being placed in the dark when open, immediately closed, and again opened on being exposed to the light of the sun, and exhibited a similar result to the frequent repetition of the same experiment. The Anthemis Maritima (Sea Chamomile), which keeps its florets closed through the night, uniformly opened them on exposure to the light of the lamps.

M. Decandolle's experiments farther shew, that although light exerts so decided an influence on the generality of plants, there are some which seem insensible to its stimulus. The habits of the Oxalis Incarnata and Oxalis Stricta were

not at all changed by continued exposure to the light of the lamps. For several days the Mimosa Pudica, subjected to similar trials, exhibited a very different and curious result. Two of these plants were exposed at eight in the evening, their leaves being closed at the time, to the continued action of the lamps: they opened at two in the morning, one hour and a half before plants of the same kind which remained in a green-house, and closed at three in the afternoon. On the following day, they did not open until midnight, and closed at two in the afternoon. Two other Sensitive Plants were placed in the cave, which was darkened through the day, and enlightened at night: these plants changed insensibly their hour of sleep, and on the third day opened at night and closed in the morning; and on being afterwards exposed to the open air, they gradually resumed their natural habits. The leaves of the Hedysarum Gyrans were found, under the experiments of M. Decandolle, to continue their

movements through the whole night, the same as in the day; but there is no detail given of the means made use of in the treatment of this peculiar plant; and, indeed, we find the account given of M. Decandolle's experiments deficient in that minute accuracy which ought always to accompany the report of such researches. The precise degree of heat made use of in the caves is not mentioned; and although the experiments are said to have been instituted in two different caves, that which was heated by a stove is not taken notice of; nor is it said in what manner light was obtained on the inside of it. In the experiments made on the Oxalis Incarnata and Oxalis Stricta, it is not stated whether they were made upon the flowers or leaves of the plant; from which, probably, there might be material difference in the result. It appears, however, as the petals are not specified, that it was the leaves of the Oxalis which were subjected to this ingenious trial. M. Willedenow, in his Principles of Vegetable Philosophy,

observes that the leaves of Hedysarum Gyrans cease to move in continued heat; but does not note the degree of heat, nor the exact time that the plant will remain in that heat before its tremulous motions subside. These observations, however, are important, as furnishing data from whence the intelligent botanist might proceed to farther inquiry.

We find great variety in the period of the opening and shutting of the petals of flowers. Their time of sleeping seems to vary according to the species of the plant, the temperature of the climate, and that of the season. There are some flowers which do not expand their corols until the heat of the sun is withdrawn: of this kind is the Cáctus Grandiflórus, commonly distinguished by the name of the Night-blowing Cereus, a native of Jamaica and Vera Cruz. This magnificent flower has a place in most hot-houses, and has long been an object of curiosity and admiration even to the most careless observer. It expands a large and beautiful corol

within which are enclosed innumerable tufts of golden stamens, about seven or eight in the evening, and emits a most fragrant odour for a few hours in the night, and then folds its languid petals, never to open more. Nyctánthes (Arabian Jasmine) also wastes its beauty on the darkness of the night, keeping its petals closely folded until the day is over, when, by the expansion of a delicate corol, it fills the surrounding air with perfume. Nor is this extraordinary property peculiar to any one species of flower, nor to any particular climate: various plants of our own country are known to have the same habits. The flowers of some species of Cucúbalus, and of Siléne (Viscous Campion), continue closed all day, but expand their petals in the absence of the sun, and emit an agreeable odour during the evening. A striking analogy may be traced in these night-blowing plants, to the habits of different species of the animal creation. We are acquainted with many insects, which appear only, after the sun has with-

drawn his rays; and there are some kinds of the higher orders of the animated world, which repose during the day, and do not come abroad until the evening commences.

The wonderful property in nocturnal flowers, of emitting their fragrance only in the night, may probably depend on the expansion of their petals, as we rarely perceive much perfume to be given out from an unfolded bud; this, however, cannot solely be the cause of their scent being withheld from the open day, as there are a variety of flowers, the corols of which continue open through the twenty-four hours, and yet are odoriferous only in a small degree, while the sun is in his meridian strength, but which fill the air with sweets in a morning before his rays are ardent, and of an evening after the force of their influence is abated. Lonicéra (the Common Woodbine), the position of whose petals does not vary, at any hour of the day, is an instance of the tendency of plants to

withhold their perfume during the heat of the sun, which may be obvious to the most superficial observer. We find, however, as great a variety in the apparent sensations of plants as of animals, respecting the influence of this luminous body: while some flowers shrink from his rays, others assiduously expose themselves to their vivifying power. Heliánthus (Sunflower), and Heliotrope (Turn-sole), have obtained their names from the uniformity with which their flowers follow the sun in his diurnal course; and the greater part of the compound flowers with ligulate petals, and some of the papilionaceous, as Yellow Lupine, have been observed daily to vary the order of their flowers, according to the position of the sun.

Nor is it alone flowers of robust form, which apparently enjoy the most ardent heat of the solar beams; Erythrónium (Dog-tooth Violet) expands its delicate petals to the utmost at the time when the sun dispenses the greatest degree of warmth. The same may be observed

in the tender corols of the Crocus, a circumstance the more curious, as, from the accurate testimony of the ingenious Professor Bradley, we are informed that the pistils of Crocus shrink into half their substance immediately upon being exposed to the influence of the sun; and this peculiarity in the autumnal Crocus is said to be so well known to the gatherers of Saffron, the pistil of that flower being the part from whence that cordial drug is obtained, that they are attentive to perform their work early in the morning, before the sun exerts his power, as at that time the pistils are most prominent. Mr. Bradley asserts, that he witnessed nearly an hundred trials of Crocuses, in all of which the pistil was found more or less contracted, according to the degree that the corol was expanded.

Nor was this phenomenon supposed to be peculiar to any particular species of Crocus, but was observed to take place equally in the garden spring Crocus, as in the autumnal kind. Mr. Bradley was first

made acquainted with this curious fact by Mr. Moreland, who had paid an accurate attention to flowers, and had uniformly observed the pistil of Crocus to withdraw itself on the approach of the sun, and to contract its parts, as if to shelter them from the influence of his rays. The cause of this apparently singular fact does not seem easily to be explained; an accurate series of attention to the habits of the various parts of fructification, with the effects produced upon them by exposure to the warmth and light of solar rays, or perhaps from artificial heat and light, are the only means by which we can hope to elucidate such phenomena; and it is by facts so well attested as the above, that the youthful botanist will be frequently excited and directed in his research after the final cause of these agreeable secrets of nature, and will, in his turn, bring forward others equally worthy to excite emulation, and of becoming the subject of accurate inquiry.

In flowers in general, the motions of

their petals seem directed to the protection of the other parts of the fructification, and peculiarly adapted to the nurture and security of the stamens and pistils. In this curious circumstance, respecting the flower of Crocus, it appears that the pistil suffers from the exposure to which it is subjected by the wide expansion of the corol; but we must not hastily decide upon the cause of an effect produced by a circumstance apparently differing so widely from the habits of vegetable nature. Nor must we implicitly rely, even on the authority of Mr. Bradley, for the accuracy of a fact so extraordinary, without subjecting it to our own examination. From some cursory observations made by myself on the Vernal Crocus, I could not discover any change in the appearance of the pistil, from the first unfolding of the petals to the widest expansion of the corol; notwithstanding which, I by no means doubt of the result stated by Mr. Bradley, as proceeding from his repeated trials. Nor can one experiment be

esteemed sufficient to overthrow a fact so respectably supported.

I have this spring had an opportunity of observing the very forcible effect which light and heat are capable of producing on the flowers of the Vernal Crocus; and, although my remarks were not attended with that precision necessary to all valuable experiments, nor pursued to sufficient length to establish any particular position, they may, perhaps, not improperly find a place amongst "Sketches of the Habits of Vegetable Life." From two small pots, filled with the bulbs of Crocus Vernalis, early in March, in full bloom, and which had stood in a hall, the general temperature of the air of which had preserved the plants kept therein from freezing; I took one about eight o'clock in the evening, and placed it in a room constantly lived in, and which, at the time the pot of Crocuses was brought into it, was warmed and thoroughly lighted by a brilliant fire and the blaze of two candles. The flowers, when removed from the hall into

this room, were perfectly closed; in less than ten minutes after their change of place, their petals began to open, and by degrees their corols became fully expanded, and continued so for three or four hours; at the end of which period I ceased to observe them; but in the morning I found them closed. The flowers remaining in the hall, which was lighted only by a single lamp, continued unchanged in their appearance, and frequently kept their flowers closed through the day, when the atmosphere was gloomy; but upon being brought into a room affording them warmer air, or upon being exposed to the immediate action of the sun's rays, their petals would open to their utmost extent. This would also occur in the flowers, when separated from the root, and placed in a glass without water. Nor did the flower lose either life or vigour during the three or four hours that it was exposed to this trial; but if afterwards preserved in water, would exhibit the same result to a similar experi-

ment the following day. The same sensibility to the effect of artificial light, was shewn by the common Blue Anemone of the Woods, a flower of which, having been kept in water through the day, was brought about eleven o'clock at night, the petals being perfectly closed, into a room lighted by fire and candle; in less than a quarter of an hour the corol fully expanded, but differed from the Crocus, in being found in the same state the ensuing morning.

All plants shew a strong disposition to expose the inner parts of their corols to the influence of light; and flowers planted on a border, near a house, will, with great pertinacity, arrange themselves most advantageously for the attainment of that important point. Nor is it warmth alone that they seem to seek in the exposure of the interior surface of their petals or foliage to the action of the sun; plants in hot-houses assume that posture, whereby the front of their corols and leaves may be most exposed to light, in preference to

that by which they might obtain an increased portion of heat from the flues, or of air from the apertures through which the warm air is admitted. The theory of vegetation, lately promulged by Mr. Andrew Knight, seems in part to elucidate the use derived to leaves from their exposure to the action of light; as his ingenious experiments seem to prove, that it is from the foliage of plants that an annual addition of wood is formed in the vegetable structure; and that, when the leaves are deprived of the influence of light, the quantity of alburnum, or new wood, produced is very small; but the benefit which accrues to flowers, from the action of this subtle fluid upon the inner surface of their petals, remains yet unexplained, unless the hypothesis of the late ingenious Dr. Darwin be admitted, which supposes the corols of flowers to form a pulmonary system for the use of the fructification only, in a similar manner to that by which the green leaves are now pretty generally believed to exercise the function of lungs to the whole plant.

The same pertinacious pursuit of light may be observed in leaves, when separated from the main stem, as that which takes place while they remain attached to it; and experiments upon Vine leaves, taken from the plant, and suspended by a thread, have shewn them to make the same efforts to display their upper surfaces to the light, as before they are removed from their natural situation of growth *, resembling, in this, the corol of the Crocus flower, when divided from the parent root, and evincing the power of motion to reside in the leaf and flower, independently of their connection with the plant in general. The sword-shaped leaves and those of Viscúm Album (Misletoe), appear to have both surfaces alike; and hence we see them retain the same position in whatever situation, respecting light or shade, they may be placed. Although the petals of flowers expose their upper surfaces to the light as pertinaciously as the foliage of plants, there is

* Mr. Calandrini, from Dr. Smith's Introduction to Botany, page 208.

an obvious circumstance of difference in the effects produced upon them by that fluid. Green leaves lose their colour by being immured in darkness, as may be daily seen in the management of gardeners in blanching their culinary vegetables; as Celery (Apium Gravéolens), Sea-Kale (Crámbe Maritíma), Endive (Cichórium Endívia), and various other plants; but the flowers of Tulip and Crocus, when kept in darkness, are said to retain the colour of their petals, which seems to shew that it must depend on a different principle from the green with which leaves are tinged: hence, in this particular, they do not suffer from the deprivation of light in the same manner as the foliage.

The motions of the different parts of fructification are still more interesting than those exhibited by the green leaves, and even in a greater degree seem to evince the faculty of sensation in vegetable life. These motions, however, are, by some ingenious writers, wholly ascribed to irritation, and have even been supposed to

take place only by the interference of an insect, or some other external agent; and that the impressions, thus made, do not extend farther than the organs which receive them *. That the various movements of the different parts of plants cannot depend simply upon irritation, may be shewn by these movements taking place in the absence of the irritating material, and when no insect is near the flower: and that their contraction frequently depends on a disagreeable sensation in some distant part from that where the motion is excited, is evinced by the exertion of the supposed muscles about the footstalk of Mimósa Sensitíva, when the other extremity of the leaf suffers an injury. To confirm the fact, that the irritation, excited in plants, extends beyond the part immediately affected, and thence to evince a union of nerves, Dr. Darwin † slit a leaflet of the Mimósa Sen-

* Mr. Payne Knight on the Principles of Taste, chapter iii. section 6.

† Dr. Darwin's Phytologia, section viii. p. 132, on the Muscles, Nerves, and Brain of Vegetables.

sitíva with sharp scissars, and some seconds of time elapsed before the plant shewed symptoms of having felt the injury, and then the whole plant collapsed as far as the principal stem. He afterwards put a small drop of oil of vitriol on the buds in the bosom of another Sensitive plant, and, after half a minute, the whole leaf fell, and rose no more.

A curious instance of irritability, in some of the species of the Mullein Genus, has been observed by M. Correa. On two or three smart blows being given to the stem of the Vérbáscum Pulverulèntem, with a cane or stick, in still, warm weather, all the blossoms opened, and, although not immediately loosened, in a few minutes fell off, separating one after another from their base, the calyxes closing round the germ, and seeming to push the corols off; the effect produced on them proceeding from external violence on a distant part *.

These sensitive motions are likewise

* English Botany.

observable in some of the stamens of the flowers of the class Syngenesia, as all the filaments contract, although one only suffers external injury. In the Bell-flower tribe of plants, we find different modes of disposing their corols, so as best to protect the stamens and pistils, included in them, from the injuries of cold and moisture. Some effect this important point by closing their apertures spirally, as Convolvolus and others. Many of the Lilies hang their apertures downwards, and, by this pendent attitude of the corol, completely shelter the anthers and stigmas from the injuries of the weather. The elegant formation of the flowers of Amaryllis Formossissima and Hemerocállis, enables them to protect their stamens and pistils, not only from the cold or moisture of the atmosphere, but also from the baleful effects of too rude a gale. These beautiful flowers, being placed upon slender footstalks hanging obliquely towards the horizon, have the power of turning, like a weather-cock, from the wind. But it is

not alone in the preservation of their stamens and pistils from the injuries of the atmosphere, that design may be traced in the motions of the corols and and other parts of the fructification: we may observe in their various directions what may be termed a vegetable impulse, by which they seem guided to the preservation, as well as to the production, of their offspring. The beautiful Umbel of Dodecatheon (Meadia) derives its peculiar elegance from the pendent direction of its flexile peduncles; by which position the pistil, being much longer than the stamens, receives with more certainty the dust of the anthers. The fertilization of the seeds being thus secured, their protection is to be next provided for; and this we see effected by a sudden change of position in the footstalks, from a pendent to an erect position; the former rendering the seeds liable to be lost before they have attained to a state of maturity, and the latter preserving them securely in their seed-vessels, until ripe for disper-

sion. The most luxuriant ears of wheat, which apparently bend under their own weight, while in blossom, raise their spikes to a perpendicular direction as soon as their anthers have performed their office of fertilization to the seminal progeny. The same change occurs in various other plants. In Fritillária Imperiális (Crown Imperial), it is the more remarkable, from the contrast betwixt the beautifully pendent corols previous to the dispersion of the anther-dust, and the stiffly erect seed-vessels after the fertilization of the seeds has been effected. In those plants which have no seed-vessels, the calyx or corol, but most commonly the calyx, performs the important office of nurturing the young progeny in its bosom, and of committing it to the earth when arrived at a state of maturity.

The Onopórdum Acânthium affords an instance of protection and nulture of the young seeds, without any effort in the plant for their dispersion. When the flowering is over, the innermost scales of

the calyx unite strongly together, and enclose the seed: nor do they again open, nor is the seed committed to the earth, until by the weather the calyx is decayed, and drops to pieces; at which time the seeds make their escape, fall into the ground, germinate, and renew their species. On the contrary, in Cyclamen there appears peculiar attention to the secure lodgement of her seeds within the soil. No sooner have they received the prolific influence of the anther-dust, than the peduncles, on which the germs are placed, twist themselves spirally downwards, until they bring the seed-vessels in contact with the earth, into which they are said forcibly to penetrate, in order to deposit their precious burthen for the purpose of germination.

Arachis Hypogæa derives its trivial name (subterranean) from hiding in a similar manner its seeds in the ground. The branches of this plant trail upon the earth, with their flowers, which are produced singly on long peduncles: as the

other parts of the fructification decay, the germ thrusts itself into the soil, where the pericarp is formed and ripened. In both Cyclamen and Arachis the interment of their seed-vessels takes place immediately after the fertilization of their seeds; so that the proximate cause of these extraordinary efforts cannot be explained by that vegetable impulse, observable in most plants, by which they are directed to the dispersion of their seeds, when ripe, into such places, and in such states of the atmosphere, as are best adapted to their future prosperity. It would seem that the seeds of both Cyclamen and Arachis might receive from the earth some material that contributed to their growth; but our knowledge of these wonderful facts of vegetable existence is yet too circumscribed to admit of any thing further than diffident conjecture respecting the final cause of such phenomena. These facts may, however, form the base of useful and interesting experiments, to which the young stu-

dent in this agreeable branch of vegetable physiology cannot pay too accurate an attention.

In the larger flowers of the Hexandria class, the approach of the stamens to the pistils may easily be observed, and affords strong evidence of vegetable spontaneity. In the beautiful poem of the Botanic Garden (Part Second, page 14), there is a curious account given of the motions of the stamens and pistils of the Gloriósa Supérba, with an elegant representation of this handsome plant, and a note, remarking various flowers wherein the curious movements of these important parts of fructification are most conspicuous. Nor do the motions of the stamens take place always at the same time, but seem to be regulated by the period at which the pollen contained in the anthers becomes mature.

In the class Didynamia (Two-Powers) the two lower stamens arrive at maturity before the two higher. After their anthers have shed their dust, they turn themselves

outwards, and the pistil, continuing to grow a little taller, receives the farina of the higher pair. Adóxa (Moschatel), Lychnis (Campion), Saxifraga (Saxifrage), have two distinct sets of stamens, which attain maturity at different periods; and perhaps it may be found, that there are not any flowers the stamens of which become mature at the same time.

In those flowers which have numerous sets of stamens of nearly an equal length, the duration of the perishable parts of fructification is very transient. In Cistus Labdiníferus, the petals and the stamens exist at most but twenty-four hours from the first expansion of the corol: so that in this delicate flower the approach of the anthers to the stigma may without difficulty be observed. The date of life enjoyed by Cáctus Grandiflórus (Night-blowing Cereus) is yet more fugacious, not exceeding a few hours; herein resembling that species of insect called Ephemera, which is said to na-

dergo transformation from the caterpillar to the winged state about six o'clock in the evening, and to exist no more at twelve o'clock at night; having, however, like Cáctus Grandiflórus, left a young progeny behind, by which to perpetuate the species. The periods of existence of flowers and insects, in their state of highest animation, that of the expansion of their petals, and the development of their wings, varies with their different species: most insects, after their transformation into the winged state, are short-lived; and the generality of flowers continue only a very contracted period after the unfolding of their petals, which may be esteemed their final change. But the wonderful fecundity of both the vegetable and insect tribes well secures the continuation of their kind. There are, however, but few species of either flowers or insects, whose lives are limited to so short a date, after their last transformation, as the Cáctus Grandiflórus and the ephemeral flies.

In those flowers which have two sets of stamens, the dispersion of the anther-dust is as slow in its progress, as in Cactus Grandiflórus and the Cistus tribe we have observed it to be rapid; and some insects are known to continue in their butterfly, or winged state, many weeks. This process is extremely slow in the flowers of Parnássia Palustris. The five stamens of this curious flower are placed alternately with five bunches of nectaries: the stamens rise one at a time, bend their anthers over the stigma, shed their dust, and then fall back betwixt the clusters of nectaries. I have observed, in some of the flowers of this plant, the approach and receding of the stamens to continue five days; in others, I have remarked that two stamens have risen at the same time. When all the stamens have discharged their pollen, the petals, with the withered stamens, all rise together, and close round the pericarp; which situation they preserve until the maturity and consequent dispersion of the seeds.—Here we see three movements of the

stamens: two in their state of highest animation; and the third, with the decaying petals, when life is nearly exhausted. Can these movements be accounted for by any other agency than that of vegetable sensation?

In the singular genus of Euphórbia, Mr. Curtis remarked a curious circumstance, which, I believe, has not been observed in any other flower; as, out of seven stamens, only two or three appear to be of use; the three stigmas rise, with two or three stamens, above the calyx; the germ then protrudes itself from the calyx, and hangs downwards; the anthers of the two or three stamens which rose with the stigma, now appear to have burst, and the fertilization of the young seeds to have taken place, and no more stamens are seen.

Much light may be thrown upon the history of vegetable life, by an attentive observation of the habits of the fructification of plants. Nor would these habits be found difficult to investigate, the period in

which they would require attention being of such short duration; and so beautiful and delicate is the structure of every flower, that the labours of the most accurate research would be amply repaid.

In assimilating the vegetable with the animal kingdom, we are indebted to the ingenious investigations of the late Mr. Curtis for an instance of striking analogy betwixt the flower and the caterpillar tribes of existence, and which may be seen in one of the commonest weeds in our gardens and hedges. The Dead Nettle (or Lámium Amplexicáule) produces two kinds of blossoms: one, a very small, short one, like the rudiments of a flower; a little larger than the calyx; with the mouth closed, very hairy, and of a bright red colour: the other, a flower like that of Lámium Purpúreum, but much longer. The first of these blossoms, which, so far as respects the corol, is evidently imperfect, appears very early in spring, in February or March: the long and perfect flowers do not make their ap-

pearance until May or June, when they are observable on the tops of the stalks; and if the progress of the flowers be watched, the corols will be found to be gradually enlarged in different blossoms, until, the weather being sufficiently warm, they come forth fully formed. "This," Mr. Curtis observes, "is similar to what happens to a Caterpillar, which, previous to its changing into the chrysalite state, has been deprived of a proper quantity of food. From deficiency of nutriment, the fly comes forth perfect in all its parts, except the wings, which are crumpled up, and never expand. In the same manner the flowers of Lámium Amplexicáule, from deficiency of warmth, are not able to put forth expanded corols; but, like the ill-nourished fly, being perfect in every other part, we find the plant abounding with seeds, and the species suffers no diminution. Some peculiarities similar to this have been observed in the genus Viola; some species of which (Vióla Montána, Odoráta, and Hirta) produce flowers late

in the summer, without petals, but which, notwithstanding this deficiency, scatter around them a profusion of seeds."

The instances of spontaneous motion in various parts of plants now laid before the young student, seem to leave little doubt of some degree of sensation being the attribute of vegetable life: nor, if we credit the account given of Vallisnéria Spirális, can we hesitate to allow to the vegetable creation the faculty of loco-motion. In this plant we find habits which assimilate it so nearly to animal nature, that it would be difficult to discover any marked circumstance of distinction betwixt the flowers of this extraordinary vegetable and the caterpillar tribe of insects, even in their most animated state, that of Moths and Butterflies: for although in general we find plants fixed to one spot, like Cockles, Oysters, and various others of the lower orders of the animal creation, which, with the greater portion of the vegetable world, can scarcely be said to enjoy the power of motion; we have, in the his-

tory of Vallisnéria, an instance of the loco-motive faculty sufficient to induce a belief that the plant in which we see it obtain must possess the power of volition in an equal degree to that demonstrated by many insects. The Vallisnéria Spiralis, a plant of the class Diœcia (Two-houses), is well known in various parts of Italy. Its roots grow at the bottom of the Rhône; the flowers of the female plant float upon the surface of the water, and are furnished with an elastic spiral stalk, which extends or contracts as the water rises or falls; and this rise or fall, from the rapid descent of the river, and the mountain torrents which flow into it, often amounts to many feet in a few hours. The flowers of the male plant are produced under water, and continue submerged until their farina, or dust, is nearly mature: at that critical period they are said to detach themselves from their footstalks, rise above the surface of the water, expand their petals, and float along the river, until they arrive at the

spot on which the female plant is stationary. These male flowers are in such numbers, although very minute, as frequently to cover the whole surface of the river to a considerable extent.

Although this wonderful history is to be met with in almost every book which treats on the physiology of the vegetable kingdom, it ought not to be omitted in one, the chief purpose of which is peculiarly to excite attention to the nature and properties of that beautiful tribe of creation which most nearly assimilate it to the animal world; and, at the same time, to guard the Tyro in this delightful science from too ready a submission of his belief to facts, stated by even the most respectable authority, until he has himself investigated the circumstances on which they are founded.

The extraordinary account given by various authors of the habits of the plant Vallisnéria, certainly takes its origin from our great master in vegetable science, Linneus; by whom, in his Genera Plan-

tarum, they are simply detailed, unaccompanied by any remark on the superior degree of loco-motive faculty over other plants evinced by the staminiferous flowers in the act of detaching themselves from their peduncles. Nor does Linneus assert that this extraordinary fact had passed under his own observation. Neither do we find any of the various authors, who have related this remarkable circumstance, note it as deviating so widely from the ordinary course of vegetable nature, as it certainly appears to do: indeed, in so great a degree, that it requires the attestation of an eye witness to confirm the fact. And by the confirmation of such a fact the sensitive faculty of vegetables must surely be established. The investigation of the habits of Vallisnéria cannot even have been a matter of difficulty; and it would have been easy to have transplanted it into our own country: yet we do not find that even the ingenious President of the Linnean Society made use of the opportu-

nity, afforded him by his tour through Italy, of becoming an eye-witness of the wonderful fact recorded of this curious vegetable: nor that any one, who has detailed the phenomenon, has been personally acquainted with it.

There is one part of fructification, which lately has become the subject of philosophical attention, the existence of which, as a part of importance, was scarcely known before the time of Linneus. Every botanical student must be acquainted with this part, under the Linnean name of nectary; but the use of the sweet juice contained therein has not yet been ascertained, and forms a subject of interesting inquiry. The curious variety of apparatus in which this delicate liquid is found, constitutes a great part of the beauty of many flowers; while in others it is contained simply by the base of the tube of the corol. In some flowers it is scarcely perceptible, except to the taste; in others it flows profusely; as in Fúschia, Crown Imperial, and Arbutus. Pontedera

supposed that the seeds, in their infant state, might absorb this nectareous juice, and be thereby nourished during their period of growth; as the chick, during the process of being hatched, is sustained by the yolk of an egg. This opinion Linneus confuted, by shewing that the stameniferous flowers, which produce no seeds, were frequently found provided with honey, as Salix (Willow), and Urtíca (Nettle). These instances, however, have by some authors not been thought sufficient to overthrow the hypothesis of Pontedera: it should therefore not be wholly dismissed from the mind of the young physiologist.

In order to ascertain the use of vegetable honey to the embryo seeds, the nectaries of Aconítum Napéllus (Monk's-hood) were separated from the other parts of fructification: notwithstanding which deprivation the seeds are said to have ripened as effectually as if the nectaries had remained on the plant*.

* F. A. Cartheuser. Barton's Elements of Botany, p. 192.

Experiments made by respectable authority must be attended to, but not implicitly relied upon, particularly on a subject wherein the difficulty of investigation is so great. It is with unfeigned diffidence that I venture to doubt the validity of the opinion of so great a master, on the subject of botanical science in all its branches, as Dr. Smith, who asserts that there can be no doubt that the sole use of the nectareous juice, with respect to the plant, is to tempt insects, who, in procuring it, fertilize the flower by disturbing the dust of the stamens*. A point so important as the continuation of the vegetable species being left to the accidental coincidence of another tribe of the creation, varies so much from the ordinary course of Nature, in the fostering care observable throughout all her works, that assent cannot readily be given to such a position. And were the interference of insects essential to the dispersion of the pollen, and, in conse-

* Dr. Smith's Introduction to Botany, page 210.

quence, fertilization of the seed, it does not appear necessary to allure them by any other means than the pollen itself, with which we see Bees, in particular, issue from the blossoms of plants laden in every part; and, as they fly from flower to flower, sufficiently secure the dispersion of the anther-dust, even should their agency be necessary to that important circumstance. In plundering the flower of its honey, we may observe a different motion in the insects who make the contents of the nectaries their prey; and the ingenuity on their part exercised to obtain this precious store, and on the side of the flower the wonderful apparatus by which it is protected, render it difficult to believe that it can be placed there for the primary purpose of being fed upon by the insectile creation. In the Monk's-hood, Bees may be seen lightly resting on the flowers, while they penetrate, with their long extended trunks, the trumpet-formed nectaries, and, having secured the honey, they frequently fly away without

any appearance of pollen about them. And the beauty of the Sphynx-moth must have excited the admiration of every observer of natural objects, by the late hour at which it comes forth in the evening, and the peculiarly elegant manner in which it extracts the sweet nutritive juices of the flowers over which it hovers; extending from the mouth a very long proboscis, and hanging over the flower, while with this proboscis it procures the honey lodged in a remote part of the nectary, without apparently disturbing the dust of the anthers in any degree.

As we advance in our belief of the animation of the vegetable kingdom, the ingenious idea of the late Dr. Darwin, respecting the use of the nectareous juice, may probably be found admissible. Dr. Darwin conjectured that this nutritive and delicate fluid might be secreted by the flower for the purpose of food to the stamens and pistils *.

* Economy of Vegetation, note 39, page 107.

Nor is this opinion invalidated by the objection brought against it by Dr. Smith, that the honey is often lodged in spurs, or cells, out of the reach of those parts of the fructification*. Whatever the apparatus that goes under the denomination of nectary, it is at the base of that apparatus that the honey is found; and while so little is known of the anatomy of vegetable life, there appears no reason why we should not suppose a communication of innumerably fine vessels, by which this nutritious juice may be conveyed to the filaments of the pistils and stamens, and, through them, be absorbed by the stigmas and anthers; thus supplying them with food during the short date of their existence.

M. Duhamel, in his references to La Physique des Arbres, published in 1758, conjectures that the honey, so apparent in the calyxes of Peach and Apricot, might be for the nourishment of the stamens of those flowers; but does not extend his idea to the same use being de-

* Dr. Smith's Introduction to Botany, page 269.

rived from it to plants in general. An experiment made by myself above twenty years ago, but, from various causes, not attended to with sufficient precision to establish a decided result, tends to shew, that the honey secreted by plants has a material effect upon their parts of fructification. The experiment was instituted with a view to tracing the nectareous juice through the vessels of the filaments of the stamens and pistils of the flower of Crown-Imperial; but, probably, even in this plant, where the parts are more than usually large, and the structure peculiarly open to inspection, the fibres may be too minute to admit of the passage of any coloured fluid through them being perceptible. With a small piece of sponge, nicely placed in a quill, I took out the drops of honey from the cavities of the petals of the red Crown-Imperial, carefully observing not to touch any part of the flower with the spunge; and, in place of the natural honey, I dropped from a quill a dilute mixture of Bees' honey, with decoction of log-wood. The bells

from which I took, and wherein I replaced the honey, were quite fresh, and the anthers beginning to open. This treatment at different times I practised on several bells of Crown-Imperial. The coloured honey sometimes dried in the cavities, or ran out of them, but did not ever appear to be absorbed. In some instances the bells withered in a day or two after the commencement of the experiment; and others remained fresh rather longer. There could not be traced any appearance of the stained honey in the vessels of the filaments of the stamens and pistils, nor in those leading to the germ. Not any of the flowers from which the natural honey was taken, and replaced by the stained honey, brought their seed-vessels to perfection, but all withered on their stems.

To observe the effect upon the fructification when deprived of the nectareous juice, I robbed the petals of this delicate fluid, at about ten o'clock in the morning, and seven every evening; during which pe-

riod it became usually replaced in the degree of about one-third of the natural quantity when suffered to remain undisturbed. Those bells from which the honey was regularly taken morning and evening, did not produce any seed: two bells, wherein this operation was less closely attended to, formed very poor seed-vessels; while the bells on the same plant which remained in their natural state, brought their seeds to perfection. The anthers and stigmas seemed to wither sooner in those flowers which were deprived of their nectareous juice, and the germ certainly appeared to suffer essentially; but whether the effect produced upon the seed by the honey being taken away, was in consequence of the anthers and stigmas losing their wonted nutriment, or of the seed itself being deprived of its sustenance, is a question of importance to be determined; and the young student who may be induced to repeat the experiment, should give accurate attention to the state of the stamens and pistils

through the whole of it, as a point material to the elucidation of Dr. Darwin's hypothesis. He should also bear in mind, that, although the seed-vessels should become mature, and the seeds apparently arrive at a state of perfection, the proof of their power of germination will be necessary to establish the inutility of the nectareous fluid to that part of the flower.

The beautiful state of the natural honey in the small cells at the base of the petals, always remaining fresh, and filling them to the edge, so long as the flower retains its vigour, seems to evince some important use to be derived from it to the plant: and the power of replenishing this valuable store, shewn when it has been artificially diminished, leads us to suppose that it is absorbed by one part of the fructification, while by another part a fresh supply continues to be secreted. That the stamens and pistils are the parts which peculiarly derive advantage from the secretion of the nec-

tareous juice, is rendered probable by the periods at which it commences and ceases to flow corresponding precisely with the short date of their existence; there not being any honey found in the petals until they begin to expand; the time at which the developement of the anthers also takes place; and the quantity being very small until the corol is fully opened, the period at which the anthers begin to shed their pollen. Also, as, when the petals begin to lose their colour, and the vigour of the stamens and pistils begins to decline, the quantity of honey visibly decreases, and this nutritive fluid can be of little use to the young seeds, as it ceases to flow in the first stage of their existence; by no means being equivalent to that derived from the yolk of an egg to the embryon chick, which continues to supply that animal with nutriment through the whole process of hatching.

In a memoir given by Dr. Benjamin Barton, in the Transactions of the American Philosophical Society, we have an

interesting account of the poisonous property of the honey secreted by some species of plants, although that vegetable production is believed, in general, to consist of a material not at all different from sugar or the honey of Bees. The nectar of some kinds of flowers is said to be rejected by Bees, and that of the Crown-Imperial to be refused by all kinds of insects; yet, from Dr. Barton's account, we find that in America honey has frequently a poisonous effect upon the persons who eat of it, and, what seems to shew that this baneful quality is derived from the noxious property of the plant from whence the Bees have plundered the nectareous juice, is the curious circumstance that honey taken from the same comb will sometimes differ in the taste, colour, and effects, according as the different strata are eaten of; one stratum or portion of it being eaten without any inconvenience, while another immediately adjoining will produce deleterious consequences. An intoxicating honey is said to be the pro-

duct of Kálmia Angustifólia, and some other vegetables; and that with which the tube of Agave Americána abounds has been found to possess an acrid nature, and, in the dose of the quantity of two table spoonfuls, to evince very active properties *.

Although the interference of insects may not form any part of the great plan of nature in the continuation of the vegetable species, there are many circumstances in which they appear to be essentially serviceable to that important point; as when plants, under the artificial treatment of being immured in frames and hot-houses, have not brought their fruit to perfection until Bees have been introduced amongst the flowers, or by some other means the farina has been scattered over the stigma. Various amusing facts on this obscure subject may be seen in Dr. Smith's Introduction to Botany, Willedenow's Principles of Botany, and in other authors, and are well worthy the

* Barton's Elements of Botany, page 190.

attention of the young student. But before the dependence of the continuation of the vegetable species on that of the insect class of animal creation can be established, experiments must be made on plants growing in the open air, and under their natural climate. It is, however, sufficient to the present object of inquiry, to shew that the nectareous juice, so plentifully secreted by flowers, and so carefully preserved by a variety of beautiful apparatus, may more probably be intended for the immediate use of some essential part of the fructification, than that it should be an agent only in the fertilization of the seeds, by alluring those insects which, by their motions in feeding upon this nutritious juice, may excite that irritability in the stamens and pistils which is necessary to effect this important purpose. And that the agency of insects is not necessary to the irritability of the stamens and pistils, may be proved, to any one who attentively will observe the progress of various flowers after the ex-

pansion of their corols, or who will consider the formation of numerous genera of plants, the construction of the fructification of which renders any foreign aid in the dispersion of the anther-dust wholly unnecessary.

The power possessed by vegetable life, of the reproduction of the species, is a mark of assimilation betwixt the nature of plants and animals next to be considered, and which occurs to our observation in every tree and herb which present themselves to our view. In treating of the movements of the vegetable creation, sufficient has been said to excite the botanical pupil to seek more extended information, and fuller explanation, of the oviparous mode by which plants are propagated, and which he will find in the works of Dr. Smith, Willedenow, and Barton, before quoted. The Phytologia of Dr. Darwin ought also to be studied, as, notwithstanding his theories may in some respects be supposed to border on extravagance, they afford much informa-

tion and curious speculation whereon to found ingenious experiment.

There are two parts of seeds, which are known by the names of Albumen and Vitellus, the white and the yolk. The last was first named, and fully illustrated, by Gærtner; extracts from whose writings now form a part of every elementary discourse on the subject of botanical science; and his treatise on the fruits and seeds of plants should be understood by every systematical and physiological botanist. The analogy betwixt the animal and vegetable tribes of nature seems to be clearly evinced in the re-production of their seminal progeny; and there are plants known to exist, which, like some animals, have not yet discovered any mode of re-producing their species, but that which is termed viviparous, or bringing forth their young without the intermediate process of a seed or egg. Nor is there any variety yet known, by which the animal world is continued in its kind, that a similar mode has not been

observed in the propagation of the vegetable kingdom. The leaf-buds of trees, and those of herbaceous plants, may be properly termed their viviparous progeny; as the young bulbs produced by the large bulbs of Tulips, Hyacinths, &c. &c. commonly termed offsets, are the viviparous progeny of that tribe of vegetables, and resemble the re-production of the Polypus, which may be found in most fresh-water pools and ditches. This animal being propagated by small buds, or protuberances, which appear on the surface of its body. These buds include the young Polype, which receives its nutriment from the parent Polypus, to which it is united, by means of a communicating aperture. When the newly-formed animal has acquired a certain growth, this aperture gradually closes, and the young one drops off, to multiply its species in the same manner: in this accurately resembling those small granules which are seen on many kinds of Lichen, and from which the species is propagated; also those cu-

rious bulbs which are formed within the bosom of the leaves of Lílium Bulbíferum, or Fiery Lily, and those which shoot out from the stem and flowers of Polygonum Vivíparum, which frequently vegetate and put forth leaves while they are attached to the parent plant.

In the Agave Vivípara of East Florida*, after the flowers are fallen, the seeds are said frequently to vegetate while they remain on the tree which gave them birth, and to put out leaves of three or four inches long: so that the plant appears alive with the young progeny. This, however, seems a distinct mode of vegetable viviparous product, and differs from that which takes place in Lílium Bulbíferum, and the animal offspring of the Polypus, in proceeding from the seminal progeny of the Agave; and seems to require farther investigation. The vegetation of seeds while they remain on the parent plant, we have too frequent instances of in wet seasons of harvest,

* See Dr. Barton's Elements of Botany, page 58.

when the ears of corn often become covered with seminal foliage from the germination of the grain.

A yet stronger analogy prevails between the Dart Millepes and the Water Lentil. The Dart Millepes multiplies by spontaneous separation, and divides, about two-thirds below the head, into two distinct and perfect animals, and seems to possess no other mode of continuing the species. The Water Lentil, a small plant which covers the surface of stagnating pools, multiplies its kind by detaching thin films from the under side of the leaves; and these films produce roots, and vegetate into regular plants.

The more general mode of the viviparous progeny of vegetables, is the young buds remaining on the parent plants; as is the case in all trees, and those plants which are called creeping: and although the newly-formed Polypi continue upon the parent animal long enough to throw out fresh Polypi to several generations, they finally separate from

her body. In the Wires of Strawberry, the joints of Mint, Couch Grass, and of various plants, which, from this circumstance, are termed creeping, the young buds closely resemble the Polypi in their multiplying to infinity; but their similarity fails in their continued union with the vegetable parent; which is seen in the astonishing length of bud and root which may be drawn out of the ground of any of these kind of plants, and which, if cut into pieces, will, from every piece, form a plant perfect in all its parts, and in every respect resembling the old root from which it originated.

Although, in point of remaining attached to the parent stock, the analogy between these vegetables and the Polypi fails, we find in the Tape-worm (Tænia) a striking resemblance in every particular. This pernicious animal is described by Linneus as growing old at one extremity, while it continues to produce its species at the other; each new Tape-worm, and each new plant, being chained to the one

from whence it springs, and continuing to form fresh ones, to an extent beyond calculation. We find also in the Tænia other striking analogies to the vegetable creation: neither brain nor nerves have been observed in these animals*. Nor are they supposed to have any particular organs of sense, the perception of touch being the only evident source of intelligence which they possess.

The accounts given, by different authors, of a variety of other beings of the lower orders of animal creation, correspond so nearly to the habits of the vegetable world, as to render it very doubtful whether a marked distinction will ever be discovered between these two great orders of nature. As in the modes by which animals reproduce their species there is a wonderful variety, so in the reproduction of vegetable life we do not find any single method to which the renewal of the kind is restricted. In the seminal progeny of plants, and that of

* Mr. Carlisle on Tænia, Linnean Transactions, vol. II.

animals from eggs, the young vegetable and animal, as soon as they are arrived at full growth, are capable of producing others, in the same manner that themselves have been brought forth by the parent which gave them birth. In the viviparous generation of plants and of animals, we find the parents throwing out from their bodies beings perfect in all their parts, and resembling, in every respect but size, the individuals from whence they take their origin. In the vegetable creation, neither the product from seed, nor that from the bud or bulb, is capable of re-producing its species, except by the formation of viviparous progeny, until it has undergone several successions of renewal: and this is believed to be the case with the Polypus, Tænia, and other animals of the same class of existence.

In trees, the buds pass through many generations, from their first appearance within the seed-lobes, to their state of highest perfection, that of bringing forth

seminal progeny. These buds annually form leaf-buds, or viviparous product, only, until, after a succession of years, they arrive at a state of maturity, when they produce innumerable buds, which continue the species by their seeds, at the same time that the tree continues to increase by the formation of new leaf-buds, which are annually renewed and improved until they also bring forth flower-buds. And this double mode of increase is now known to take place in the Polypus; and that, after having brought forth, in the course of the summer season, multitudes of small animals perfectly formed, in the autumn she deposits eggs, which evolve themselves into young Polypi.

In bulbous roots, obtained from seeds, several years pass, during which period the bulb renews itself annually; producing leaf-bulbs, or viviparous progeny, alone; until at length it acquires the power of generating flower-bulbs, which propagate the species by an oviparous

product. From this period, Tulips, Hyacinths, and many other kinds of bulbous plants, perhaps all, produce certainly one bulb annually, and probably more, which bears a flower; and many smaller bulbs, which undergo a yearly renewal for a certain time, before they bring forth a bulb capable of forming oviparous product. The same successive changes may take place in the viviparous progeny of animals; and, from the close analogy between the habits of the Polypus and viviparous vegetables in other respects, it may not be unreasonable to suppose that they will be found to resemble each other in this particular also.

Although, in trees, the leaf-buds remain attached to the plant on which they are formed, they may properly be esteemed individual beings, as they are perfect in all their parts, and capable of becoming in all respects similar to the parent tree, if separated from the branch on which they grow, and with care placed in the earth, and properly supplied with mois-

ture; as the bulbs which fall from the Tulip and Hyacinth continue the species by producing plants similar to themselves. These viviparous buds, however, although they re-produce, they do not renovate the species, but have been proved to partake of all the habits and nature of the parent plant; insomuch, that the experiments of the ingenious Mr. Andrew Knight have shewn, that it is not possible to eradicate the disease of any species of vegetable by propagating the buds of a decaying plant; which failure he ascribes to old age alone. Dr. Darwin, however, suggests a different cause for this curious fact, and ascribes the degeneracy of the species, which renews itself only by buds or bulbs, to the want of mixture with others of its kind, the viviparous product being repeated through a series of years from the same substance, whereas, in that obtained from the oviparous mode of increase, a variety is introduced, which, by that celebrated philosopher, was esteemed essential to the continuation of animal or

vegetable life in its pristine perfection. And that the decay of Apple, Pear-trees, &c., which are propagated by the bud or graft, arises from this cause, is rendered probable by the well understood fact, in those countries where potatoes form a large part of the husbandry, that, since the practice of renewing that valuable vegetable by seed, the disease, known by the name of curl, scarcely ever occurs. And the potatoe growers, who have most attended to the subject, believe that, to avoid this distemper, it is necessary, in a certain number of years, to renew the species by oviparous or seminal product.

The decline of plants not renewed by seeds, is also well understood by florists; bulbous roots have been found by experience to decay, if propagated only by the bulb; and experience has shewn, that no art nor care can preserve them in vigour, although change of soil and other kinds of nurture may prolong their existence. The roots of Ranunculus are said

to decay, from the time of their having been raised from seed, in seventy-five years; those of Anemone in fifteen; and of Hyacinth in twenty-six *. At the same time, respecting trees, and therefore probably other plants, renovation to a certain degree, it is believed, may be obtained. If an Apple-tree, perishing under the disease of canker, be headed, the stem will bring forth buds, and those buds branches, which will increase in vigour until having passed through a successive series of viviparous product, the flower-buds, or oviparous progeny, are formed, after which period the tree begins to shew all the disease it had exhibited before it was cut down, and partakes of all the decrepitude of its contemporaries. This, however, is mentioned with diffidence, as the experiments, tending to investigate this circumstance, were not pursued with sufficient preciseness to establish the position.

All gardeners are acquainted with the

* Madoxe's Florist's Dictionary, page 91.

greater difficulty of preserving the life of many plants, after they have borne flowers, than previous to the period of their fructification; and Mr. Rose, in his Elements of Botany, gives a curious account of the Corypha, or Umbrella Palm-tree, and the Plantain-tree; the first of which produced leaf-buds, only, for the space of thirty-five years, and, at the end of that time, brought forth flowers and fruit, and died. The Plantain-tree is said to have continued in the gardens of Holland a hundred years before it has produced flowers, and immediately after that period always to have lost its existence. The Lavatéra Arboréa is reported to rise to the height of a common Pear-tree, bearing the winter frosts without injury; but having once blown, although it should produce but one flower, no art can preserve its life on the first approach of the cold of winter. These are curious facts, well worthy the attention of the ingenious botanist.

The word progeny, as applied to the

leaf-buds of trees, has been objected to as one to which the idea of youth is peculiarly annexed, whereas, it has been said, a *seedling* Tulip is a young plant, and requires several years to attain the power of re-producing blossoms and seeds; but the new *bulb* being generated with the habits of mature age, cannot be esteemed a new existence, but must be considered only as a continuation of the mature plant, partaking of the nature of the parent vegetable, whether that be unproductive infancy, or debilitated old age. An attentive observation of leaf-buds and leaf-bulbs will, however, shew that, so far from being generated in a state of maturity, they require, like the seedling bud or bulb, the successive renewal of several years, before they arrive at that state of perfection which enables them to produce blossoms and seeds; after which period they bring forth one, at least, large bulb, endued with immediate power of generating both flower and leaf-bulbs; the latter of which pass through successive re-

newals before they become capable of a similar product.

The circumstance of the mature Tulip or Hyacinth bulb, and every other bulb which has arrived at a state of maturity, producing annually flower-bulbs and leaf-bulbs, is strictly analogous to the habits of trees and herbaceous plants, which, when arrived at the state of perpetuating their species by oviparous product, bear yearly both leaf and flower-buds on the same plant. Our knowledge on this interesting subject is, however, yet in its infancy; and perhaps that of the habits and nature of viviparous animals yet more so. If, however, the miniature Polypus or the viviparous product of various other animals, may be termed progeny, there does not appear any objection to using the same term respecting the buds and bulbs thrown out by vegetables; and whatever term may be used, the analogy equally prevails.

Another and striking point of connection betwixt vegetable and animal life,

is found in the capability possessed by various species of each order of nature, of being propagated by every particle of matter from which they were originally constructed. The twigs of trees, and the bodies of Polypi and Worms, may be divided into innumerable portions; and in each portion there remains an inherent property of becoming a new plant or a new animal.

A yet more curious analogy is observable between the Polypi and engrafted vegetables; the latter, it is well known, may, by the art of inarching, be united in as great a variety as the imagination can suggest; and the curious experiments of M. Trembly and others, have evinced that the same may be effected on the fresh-water Polypus. Different portions of one Polypus have been engrafted upon another; two transverse sections have been found to unite in a short time, and form one animal; the head of one kind may be engrafted on the body of another species of a different colour, and will

quickly form a motley whole; but whether the engrafted Polypus puts forth distinct kinds, corresponding to the species united by art, seems a point that has not yet been observed upon. In the operation of engrafting vegetables, we see different sorts of Apple and Pear unite with a trunk of a different species, and each scion producing its appropriate fruit.

The subject of the union of different kinds of vegetables, by the art of inarching or engrafting, is not, however, yet perfectly understood. That the stock and scion should be of the same natural family, is a point by all gardeners deemed essential to their junction; but whether the graft is in any way affected by the properties of the stock into which it has been inserted, is a question yet undecided. Some of the most ingenious writers on this subject esteem the plant, on which the bud is engrafted, as exercising no effect whatever upon the scion to which it has been united; but we must not overlook the opinion of many inge-

nious practical gardeners, who believe the fruit of the graft to be materially influenced by the juices of the stock on which it grows; and that an Apple will be more or less acid, according as it is engrafted on a crab-stock or one of a less poignant kind; and that the buds of Plums and Cherries, inoculated into other species of the same genus, will not produce fruit exactly resembling that of the tree from which the grafts were taken. This opinion is the more worth attending to, as it is countenanced by that of the ingenious Professor Bradley. In his Treatise on Gardening and Husbandry, he details much curious matter in support of this belief*, and brings it forward in proof of the circulation of the sap in vegetables. He asserts, that by inarching any striped kind of Jasmine, or other variegated plant, into a plain common sort, that the stock will become infected by the disease, which occasions the spots and stripes of the scion, and will, in conse-

* See his Letter to Dr. Douglass, vol. ii. p. 237.

quence, put forth leaves of the same kind; and that, on the contrary, the motley foliage of the part engrafted may, by carefully inarching the scions into healthy stocks, be brought back to its genuine verdure.

It must be remarked, that these observations are not the result of Mr. Bradley's own experiments, although they are derived from authority highly respectable. He gives us, however, one fact of importance, which passed under his own inspection: he relates, that he had joined healthful, vigorous stocks, with old, decaying trees of the same species, and had, by that means, brought those old trees to recover their pristine vigour.

I have dwelt the more fully on this intricate point, in the hope of inducing the botanical student to institute experiments for the further elucidation of this curious part of vegetable history. The junction of the yellow with the green species of Willow, like the union of the different coloured polypi, might enable

him to investigate the subject more clearly: and in experiments made for the purpose of restoring vigour to decaying trees, by engrafting their scions into healthy stocks, it will be necessary, to render them complete, at the same time, and under equal circumstances, to engraft also scions into stocks which are diseased; and should the plant be one which will throw out roots from cuttings, a few twigs, placed in the soil, would enlarge the scope of observation, by affording an additional subject of comparison. It must, too, be remembered, that the viviparous product of a diseased tree, when separated from the parent stock, will flourish for some years in whatever situation it may be made to grow, and might hence mislead the young practitioner into the belief that the renewed vigour of a scion, taken from a decaying tree, ought to be ascribed to the influence of the healthy stock.

There is an order of plants which must not be overlooked, although they

are usually considered the lowest of their kind, as they have been supposed to assimilate more closely to the animal creation than any other class of the vegetable world. The Fungi resemble animals, in some of their species, in growing vigorously without light; as is shewn by those found in dark cellars, and by the Truffle, which lives and vegetates under ground. And they have been found equally capable of conducting the Galvanic fluid with animal matter. But although this property may be possessed by the Fungi in a higher degree than by plants in general, we have seen that it does not form any exclusive distinction betwixt them and other vegetables.

The animal flavour of the esculent Mushroom, and the odour of any kind of Fungus, when burned, resembling that of burning feathers, added to the putrefaction to which the whole tribe are subject, and the scent emitted by them in that state, do not exclude them from the vegetable kind, but afford additional

analogical evidence of the affinity between the two kingdoms. The Lycopérdon Tuber (Truffle) grows under the earth, and remains there the whole period of its existence. M. Builliard considers the edible Truffle as a viviparous vegetable, and asserts that the grains found within the cells of the fleshy substance are not seeds, as has been supposed, but small Truffles already formed, as they have the same figure and colour as the parent plant; that they have, like it, their surfaces covered with little pointed eminences; and that, in arriving at their complete size, they do not develope themselves, like seeds, but grow by a simple extension of parts, by means of the minute points which cover their surface, and which become prolonged into short threads, or fibres, by which they draw from the parent Truffle the juices necessary to their growth; in all these respects curiously and accurately resembling the well-known progress of the viviparous Polype. By the fibres through which

the young Truffles have drawn their food, they are said to fix themselves in the earth after they are separated from the mother-plant; the young Truffles still visibly preserving those fibres, which only disappear by age.

Wide is the field on which ingenious research may be exercised in the investigation of the habits of the whole vegetable creation; and there is no part in that beautiful division of the works of nature, wherein the botanical world has so much to learn, as in the Cryptogamic orders of the Fungi and Fuci, nor in which there may probably be discovered so close an analogy to animal life.

The means by which the vegetable order of nature is sustained, is a question which has powerfully attracted the attention of all botanical philosophers, and seems to form the most distinguishing point betwixt the animal and vegetable creation. This supposed distinction must, however, be confined to the adult vegetable, as during the state of infancy a striking

analogy takes place in the material with which the embryon plant and animal are nourished; as each is plentifully supplied with a store of saccharine and lactescent juices, which it absorbs, through vessels communicating from the parent to the infant vegetable or animal, so long as either continues attached to the being which gave it life, or until it has attained its full dimensions.

The provision made for animals in their embryo and infant state, is universally understood; and a slight degree of observation will evince an equal attention in nature to the preservation of her vegetable children during their first periods of existence. Seeds have been shewn by Gærtner to contain two kinds of sustenance, resembling the white and yolk of an egg, which are visibly absorbed by the embryon seedling through its early stages of growth. The buds of trees are also provided with nutriment of the most delicious kind, resembling sugar in its taste. That flow of sweet sap,

found only during the infant state of the buds of trees, is apparently intended as a supply for their support, until they have acquired organs whereby they can inhale the juices of the earth. The Birch and Maple trees are, during the spring months, replete with nutritive saccharine matter, which continues until their leaves have attained their full growth. In their half-grown state, the leaves of Birch have a fine aromatic smell, are glutinous to the touch, and, when seen through a good microscope, have the appearance of being encrusted with a fine sugar, which, to the taste, is as sweet as that of the sugar-cane. Bulbs are supplied with sustenance during infancy from the juices of the parent bulb, from which they take their rise; and we have seen the same mode of support in the viviparous progeny of Lycopérdon Tuber, and which may be observed in various other vegetables.

The food of adult vegetables, so far as the materials which compose their nutriment are understood, consists of mere

earths, salts, or airs; and this, by M. Mirbel, has been supposed to form an impassable line between the animal and vegetable kingdoms. It should, however, be remarked, that those earths which are most salutary to vegetable life are formed by the decomposition of various matters, which, under a different modification, might serve for the sustenance of even the higher orders of the animal creation; and the component parts of salts and airs, with the food by which the lower tribes of animal life are sustained, are not, perhaps, sufficiently understood to induce us hastily to admit M. Mirbel's observation as an hypothesis not to be controverted. Yet, however well it may be founded, even here modern research has furnished us with some analogy; and if we may rely on the account of M. Humboldt, in his Travels in South America, we have an instance of mankind subsisting upon earth for three months. M. Humboldt informs us, that the people known under the name of the

Otamoquas, when deprived, by the height of the river Oronoqua, of their usual food, the tortoises, eat scarcely any thing but a kind of fat earth, without any further preparation than that of burning it slightly, and rendering it moist.

On a subject so obscure, it may not be amiss to bring forward even doubtful facts, which are capable of being opposed to established belief. But we must not too much rely on the deduction to be drawn from M. Humboldt's account; as the earth, which he relates to have contributed to the sustenance of the unfortunate people who by hunger were compelled to feed upon it, was, when brought to Paris, and analysed by Citizen Vauquelin, found wholly destitute of any known nutritive property. It must, however, be always borne in mind, that, in seeking analogy betwixt vegetable and animal life, it is the habits of the lower orders of the latter into which we should chiefly inquire. We are not, however, without well-attested instances of the human ani-

mal, subsisting apparently upon air alone *; and as we see vegetable life supported, in its first period of existence, by food so exactly resembling the sustenance provided for the young of the animal world, we must wait the result of further experiment, before we pronounce upon this supposed failure in the analogical evidence, which, in all other respects, has been found to obtain between these two great orders of the creation; and this the more especially as our knowledge of the kind of food taken by worms, winged insects, and many of the least animated of the marine tribe of organized matter, is as much in its infancy as that respecting the sustenance of vegetables.

A more amusing and less obscure point of analogy betwixt plants and animals, is the power of habit, to which the former are subject equally with the latter; and their apparent faculty of adapting those

* See a small pamphlet, containing an account of Anne Moore, of Tutbury, Staffordshire, having lived nearly two years without food.

habits to whatever change of circumstances may occur. This assimilating quality of the vegetable to the animal creation, did not escape the investigating eye of Professor Bradley, who remarks, that every vegetable will, if possible, observe its natural time of spring and growth, whatever climate it may come from or be in *.

Seeds or plants, brought from climates and soils wherein they have been accustomed to vegetate early, will for some seasons preserve their wonted time of fructification, which taking place in a colder atmosphere, and less genial soil, perish without coming to maturity. After the first or second year, the plant learns to accommodate itself to its new situation, and does not put forth blossoms until a later period, when they may enjoy the advantages of a milder season.

This power of habit in plants may be beneficially applied by the farmer and gardener in the culture of their fields and

* Bradley on Husbandry and Gardening, vol. ii. p. 4.

gardens; and Mr. Knight found that a crop of wheat, planted on high cold ground, ripened much earlier when the seed was obtained from a very warm district and gravelly soil, which lay a few miles distant, than when it was taken from grain which grew in the vicinity *; and his ingenious experiments in the propagation of potatoes, on this principle, promise to become of extensive utility.

The whole of the writings of Mr. Andrew Knight are peculiarly worthy the attention of the horticultural or botanical student; and his agreeable Treatise on the Culture of the Apple and Pear tree, should be in the hands of every one who takes pleasure in these amusing and rational pursuits. Also his detached papers, in the Transactions of the Royal Society, afford important information in the physiological branch of botanical science. His ingenious theory of vegetation is so well delineated in Dr. Smith's valuable

* Horticultural Society.

elementary work, the Introduction to Systematical and Physiological Botany, that it would be needless here to enter further into the subject, than to recommend the whole of Mr. Knight's papers as necessary to be accurately understood by the student of vegetable nature. Nor is it to theoretical botany alone that his researches have been confined; the practical treatment of fruits and culinary plants has been greatly improved by his labours, and forms, under his view of it, an interesting and amusing subject of speculation.

The annual occurrence of the fall of the leaf, has excited the attention of all vegetable physiologists, without hitherto having received satisfactory explanation. Dr. Smith has classed this phenomenon amongst the diseases of plants*, and compares it to the casting off of worn-out and distempered parts of the animal body. Vrolick's opinion, as we learn

* Introduction to Systematical and Physiological Botany, page 342.

from Willedenow, was the same; and by that author we are also informed of the various hypotheses of different writers on this difficult subject*, with which the young physiologist in the science of vegetation should make himself acquainted.

I hope I shall not be deemed presumptuous in offering an opinion upon the autumnal dropping of foliage, distinct from any which, I believe, has yet appeared before the public. Instead of considering the fall of the leaf as the effect of disease, may it not be esteemed the result of a natural process? May we not suppose leaves to be the parents of the young buds which are found proceeding from their bosoms, by which their juices are absorbed, and which perish only when their offspring have attained their full period of growth? A circumstance so similar to the formation and re-production of bulbs, as to afford strong analogical evidence of its probability; and which is

* Willedenow's Principles of Botany, page 303.

further corroborated by its resemblance to the decay of the fructification of a flower after the maturity of its seminal progeny; and in the re-production of bulbs we see the newly-formed bulbs so dependent for their growth on the leaf of the preceding year, as frequently to perish if that be cut away.

The circumstance mentioned by Dr. Smith, of the proof of success afforded by newly-planted trees, in their leaves being easily detached from the stem, adds strength to this hypothesis. If, at the time a tree or shrub is removed, the buds annually produced are wholly or nearly formed, they no longer stand in need of that support which, during their time of growth, they derived from the juices of the parent leaves; and in a short time the old leaves will drop off, as would have happened had the plant continued undisturbed; but should the tree be removed during the infant state of the newly-formed buds, the leaves, having lost their usual supply of nutriment from

the earth through the root, do not retain sufficient vigour to perform their natural function of nurturing the embryos to which they have given birth, and, instead of their wonted process of gradual decline, as their infant progeny gradually increased in growth, they become diseased from want of sustenance, and wither prematurely upon the tree. And should the viviparous offspring continue to live, it will derive a precarious existence from other parts of the plant; the buds will be feeble and ill-formed, and will require a few successive generations of renewal, with the leaves unmolested, before they recover a state of vigorous growth.

The same occurs in the re-productions of bulbs which have been deprived of their leaves at too early an age, or transplanted at the time of flowering, when their leaves are green, the period at which the renewal of the bulbs commences; as, although by care the bulbs may be preserved alive, they will pass through the changes of two or three

years before they regain the vigour they would have enjoyed, had they remained in the soil until their leaves were decayed, and their new bulbs fully formed. If this hypothesis be admissible, it may account for the difference of time at which the fall of the leaf occurs to individuals of the same species, and under similar circumstances; as their loss of foliage will depend more upon the complete formation of the new buds, which by various accidents may have been impeded or accelerated, than on the effects of any particular season.

Nor is it only from the base of the leaf-stalk that buds take their rise: the flower-buds of a species of Ruscus proceed from the surface of the leaf itself; and the curious appearance of Fúcus Prolíferus is produced by the leaves growing out of each other. The Water-Lentil, as we have before seen, re-produces its species by casting off thin films of foliage; and in some kinds of bulbs, Tulips in particular, the young leaf-bulbs

are frequently generated in the bosoms of the stem-leaves, in a mode precisely similar to that by which the buds of trees are formed.

Dr. Darwin's theory of the individuality of leaf-buds should be well considered*; and although that part of it, which supposes the annual renewal of the bark from the radicles protruded by the young buds, seems to have been proved erroneous by the experiments of Mr. Andrew Knight, it cannot be doubted that the buds of trees possess an inherent power of throwing out roots, and of thus, when placed in proper situations, becoming plants complete in every part. During their state of infancy, and while they remain attached to the tree, buds seem to be nourished by those rich saccharine juices which abound in many different trees throughout the months of spring, and which are analogous to that store of sweet mucilaginous matter provided for the rising germ in the cotyle-

* See Phytologia.

dons of the oviparous progeny of vegetables.

After the death of the parent leaf, and the expansion of the bud into other leaves, each individual of the foliage derives its support from some material drawn from the root, which, as Mr. Knight has ingeniously demonstrated, after passing through appropriate vessels to the leaf, is returned by it into the inner bark; and in its passage downwards deposits a layer of wood, by which the bulk of the tree becomes annually increased. The matter from which this new wood is derived, seems also equally ready to form itself into root-fibres, as may be seen, if its passage down the tree be impeded by strangulation or other means. And, without the use of art, Vines in hot-houses frequently exhibit a curious spectacle, in the protrusion of numerous thick roots from the joints of the stem at the base of the leaf-buds, while attached to the parent plant; and it would be worth experiment to observe the difference of the

state of the new wood below these buds, with their roots, and that beneath those by which no roots have been protruded.

The common belief, that trees in hot climates, and the ever-green trees of our own country, are destitute of buds, seems to be without foundation: such plants as have been brought hither, and preserved in an artificial atmosphere, similar in temperature to that of their natural climate, form buds and cast their leaves yearly, as may be seen in Orange, Myrtle, and various other kinds: and in the Laurels naturalized to this climate, and in the Ivy and Holly indigenous to this soil, the fall of the leaf is as constant as that which occurs in trees usually distinguished by the term deciduous. The loss of foliage, in the class of plants denominated ever-green, is, however, much less obvious than that of deciduous vegetables, as the leaves do not wholly lose their green colour before they drop; and as their decline occurs in the spring season, the expansion of the buds is more rapid, and the tree becomes

newly clothed before the loss of the leaves of the preceding year is perceptible.

The subject of the formation of buds and bulbs is peculiarly curious and interesting; and, for the assistance and amusement of the young student, I subjoin drawings of various bulbous roots, made at different times in a course of experiments formed for the purpose of discovering the mode in which bulbs were re-produced; also of nuts and seeds, to shew the nurture and growth of the embryon vegetable. These experiments, although not pursued with the regularity worthy the importance of the subject, may prove sufficient to excite a desire to extend them, and may smooth the way to the institution of others more deserving the attention of the public.

Dr. Grew was the first vegetable physiologist who brought into notice the perfect formation of the young vegetable the year preceding its developement*; a

* Anatomy of Plants, page 173.

most beautiful process of nature, which may be seen in every root and twig which presents itself to our view; and, yet even in these times of science and research, this interesting phenomenon has not attracted general observation. A bud of the Horse-Chesnut, from its superior size, will exhibit most perfectly the formation of the flower for the year ensuing: enclosed in warm down, and surrounded by resinous scales, impervious to the weather, the flower remains many months uninjured, until, like the animal within the chrysalis, it bursts its integuments, and comes forth into open day. The same process may be seen in the minuter buds of Currant and Hepatica, and probably takes place in every other plant, although not equally obvious in those, the buds of which are not so completely formed.

The embryon flower in the bulb of Tulip, has attracted the attention of many observers of vegetable phenomena, and also the annual renewal which the bulb undergoes. But, notwithstanding the

yearly production of the bulb of Tulip, and of several other species of bulbous roots, is now well understood, the subject yet remains to be thoroughly investigated, as appears by the accounts given by various ingenious authors of the roots of Orchis, Crócus, and Gladíolus, which they describe as consisting of two bulbs, and which were esteemed by Linneus a distinct species, and received from him the appropriate term of Bulbus Duplicatus. Nor did the discriminating eye of that great naturalist lead him to discover, that what appeared to him a double bulb, was the process of the formation of a new bulb by absorption of the juices of the old one.

Our admirable herbalist, Gerrard, takes notice of the manner of growth of the bulbs of Gladíolus and Crócus, which he describes as bearing one bulb upon another; adding, that in spring the bottom bulb of Gladíolus is much larger than the top one: but proceeds no further. Had he extended his attention to these

roots a few weeks, he would have discovered that the lower and larger bulb, early in spring, diminished in size as the season advanced; and the upper and smaller one increased in growth; until, in the end, the lower bulb wholly disappeared, and one single large bulb remained, by which the species was continued. The drawings of Crócus and Gladíolus will evince this fact. The Orchis I have not had an opportunity of observing; but, from the usual progress of re-production in all other species of bulbs which have passed under my inspection, I am led to believe that the increase of that curious plant will be found to proceed according to the general laws of nature. And although the limited attention I have given to plants of the herbaceous kind, by no means renders me competent to assert the fact, I venture to suggest, that this tribe of vegetables, like trees and shrubs, are composed of numerous buds, which annually perish, their juices having been gradually absorbed by the new buds

formed under ground, at the base of their leaves, for the re-production of their species.

From the result of a few partial experiments, I have been induced to believe that the root-fibres of herbaceous plants yearly decay; and that it is not until the new buds are perfectly formed that fresh fibrils are protruded. My observations, however, on this dark subject, were made nearly twenty years ago, and at the time were so little extended, and pursued with so little vigour since that period, that I do not now presume to bring them forward with any other view than as being perfectly accurate so far as they proceeded: and upon a subject so little understood, I flatter myself the young physiologist may find them of some assistance to him in his researches into the growth and habits of the vegetable kingdom; and that they may not be found wholly destitute of practical utility in the nice art of transplanting, as, by the theory of the growth of herbaceous plants, taken

from my memorandums, it appears that, by want of attention to the period of the formation of bud-roots, twelve months are frequently lost in the growth of such herbaceous plants as are removed from one situation to another; added to which, the roots are liable to decay, and the plants to perish.

Herbaceous plants, like those of the bulbous kind, are supposed to shoot their roots down into the earth a very short time after the annual formation of their buds. If such plants are removed about the period that these buds begin to protrude their fibrils, or a little before that process, the plant, not being interrupted in the formation of new roots, will be firmly fixed in the ground before the winter season, and their buds will be maintained in health by the nutriment conveyed to them through their newly-formed radicles. If the annual renewal of roots has taken place before the time of transplantation, the roots will be destroyed or broken by that operation, and

the plants will remain loose in the soil into which they have been removed, until fresh fibrils are formed by the buds of the ensuing season. These new buds will partake of the weakness of the parent buds, until they have acquired vigour from the nutriment conveyed to them by their new roots, after which they will produce healthy buds, and the plants will again flourish.

This theory may possibly be instructive in the transplantation of trees; and if the fact should be ascertained, that the buds of trees resemble those of herbaceous plants, we may learn the proper management of one from an attention to that which best suits the other. Hence the practice of removing trees in early spring must frequently retard their growth, and subject them to destruction; as at that season the infant buds of trees are apparently nurtured by that sweet juice which nature has laid up for their sustenance, and which is not found at any other period of the year. By removing the tree at the time when this juice should

flow, the vessels provided to convey it to the buds must be broken; and hence the young progeny will be deprived of that nutriment on which the vigour of their growth depends; in the same manner as the germ of a seed is destroyed, if it be deprived of its cotyledons before it is provided with radicles through which it can imbibe the nutriment of the earth.

If trees be removed immediately after their annual buds are perfectly formed, the vessels through which these infant buds receive their sustenance will be formed before winter, and in spring there will be no impediment to their attainment of strength in that season which seems peculiarly designed by nature for the re-production of both the vegetable and animal creation.

This sketch of what may be, rather than what is decidedly known to occur in the growth of trees and herbaceous plants, must be considered by the young student as an outline, which must either be blotted out or filled up by his future researches. The analogy of the re-production of, and progress of growth

of, all bulbous roots, is certainly in favour of the theory; but he must bear in mind, that analogy, unsupported by experiment, is not to be farther admitted than as presumptive evidence of a doubtful fact, and as a guide to the direction of our inquiries. In his experiments for the purpose of confuting or ascertaining the similarity of re-production betwixt trees, herbaceous plants, and bulbous roots, he must remember, that every bud of the two former kinds is supposed to resemble the bulbs of Tulips, Hyacinths, Crocuses, &c.; and, like them, to constitute an individual being annually renewing its existence from the recrements of the leaf or bud of the preceding year. The buds of creeping plants, such as Lysimáchia Nummulária, Money-wort, Mint, and various other species of the same nature, seem to observe the same laws by which the twigs of trees are governed, and increase their leaf-buds to infinity, without detaching themselves from the stem of the parent plant. Aloe, and other succulent vegetables, throw

out young plants around their base; and the old plant continuing to live, resembles in this particular the Polypus, and other animals which exhibit so curious a re-production of viviparous progeny.

In experiments made on herbaceous plants, single buds must be separated from the general mass of roots, and planted apart; and if seedling plants are made the subject of observation, the habits of growth and re-production of their buds may be more distinctly understood. Some drawings of bulbous plants, and a few seeds of different species of trees, are annexed, to shew different states of reproduction and germination; which, although the generality of them may not contain information worthy the attention of the experienced botanist, I flatter myself will be found useful to the young physiologist, who is only entering into the depths of this interesting science.

But, however familiar, in general, the renewal of bulbs, and the evolution of seeds in their different modes, may be to the eye of the practical botanist, I

have reason to believe that the progress of the germination of the seed, or nut, of the Cocoa Palm, offers a subject of investigation equally new to both the master and pupil in this branch of botany, as I have in vain sought for information respecting this phenomenon, from various ingenious writers, who have given accounts of this majestic order of vegetables. It is nearly twenty years since the extraordinary appearance delineated in the fifth plate attracted my attention; but from ill health, and other combining impediments, I have not had it in my power to pursue those means which might have enabled me to trace this singular species of germination through the periods of its developement; an investigation which might easily be effected, by placing a few Cocoa-nuts in the soil of a hot-house, and opening them at different stages of growth; observing, that in those Cocoa-nuts in which the kernel seems to swell through the holes at the broad end of the nut, the act of germination has pro-

bably begun. It also would not be difficult to procure observations from some intelligent inhabitant of the climates to which Palms are indigenous, the quickness of vegetation in those warm countries rendering experiments on the germination and growth of plants peculiarly easy. The whole Palm tribe offers also to our view a construction differing as widely from that of other trees, as the developement of the embryon plant of the seed of the Cocoa Palm exhibits to that of all other known vegetables.

The singular structure of the Monocotyledonous class of plants has been made the object of investigation to the ingenious members of the National Institute at Paris; and a memoir on the organization of their parts, by Citizen Desfontaines, given in the Monthly Magazine, No. XI., December 1796, is worthy the attention of all botanical physiologists. From this memoir it appears that the whole tribe of plants, the seeds of which sprit with one lobe, have been found to

bear a near affinity to each other; insomuch that the humble Grass and the imperial Palm are connected by the great distinctive marks of all monocotyledonous vegetables; the structure of which is so peculiar as decidedly to separate them from those plants which germinate with two seminal leaves. Palms are said by Linneus to exceed all other trees both in height and longevity: the Cocoa Palm is said frequently to rise to the height of sixty feet; and the trunks of some of the larger kinds of Palm are reported to ascend to nearly two hundred: yet these majestic columns are described by Desfontaines as not beginning to elongate until four or five years from the period at which the seeds first germinate; during which time he observes that the plant throws out successively a number of leaves, which, by the union of their footstalks, form a bulb immediately above the root fibres. This bulb increases by degrees in size and solidity, and at length rises through the ground, and forms the

trunk; being at its first appearance as dense and thick as it will ever become hereafter; the figure being that of an exact cylinder.

Desfontaines, however, remarks, that the regularity of the cylindrical trunk is sometimes interrupted by the greater or less absorption of nutrition by the roots; and gives a curious account of this irregularity of a Cycas, a plant of the monocotyledonous order, growing in the National Garden. This plant was brought in a tub from the Isle of France, in the year 1789: it languished during a considerable time; during which state of debility the stem increased in length only a few inches, and the whole of this elongation was much less in diameter than the rest of the trunk: by slow degrees the tree recovered, the shoots became more vigorous and larger; but the emaciated part retained its first dimensions. That part of the trunk which was produced while the plant remained in its native country, was twenty-three inches

in circumference; the part above it, formed during its feeble state, fourteen; and that which made its growth after the tree was restored to health, nineteen; which inferiority from the first dimensions M. Desfontaines imputes to the deteriorating influence of a foreign climate. The fact of the emaciated shoot of Cycas retaining its original dimensions after the tree was restored to health, and had put forth a vigorous shoot, merits particular attention, as seeming to imply the independence of the annual circles upon each other, and to be similar to that which occurs in some engrafted trees, as in them the stock frequently retains nearly its original dimensions, while the scion annually increases in bulk; — a subject of much curiosity, and which requires farther investigation.

The roots of all the Palms appear to be very disproportionate to the weight they have to sustain in the earth; and Forster relates, in his Voyage with Captain Cook to the South Sea Islands, that the Cocoa

Palms abound upon ledges of Coral rock, whereon there is scarcely soil sufficient to receive their roots; so that it is a subject of wonder how these lofty trees, laden at their summits with bunches of ponderous fruit, can be fixed in the soil by a few tufts of simple fibres. Desfontaines remarks, that the Arborescent Filices (Ferns), like the Palms, have their trunks crowned with a tuft of leaves, and covered with a solid bark, composed of the fibres of former leaf-stalks;—a circumstance to be attended to by any one who may be desirous of investigating the theory of bud-roots.

In order to the right understanding of the singular mode of germination which occurs in the nut of the Cocoa Palm, that in which the generality of seeds develope the embryos within their bosoms must first be made evident. From the very material difference shewn by M. Desfontaines in the structure of the monocotyledonous and dicotyledonous plants, it may be supposed that the seeds of these two orders

preserve an equal distinction in their mode of germination; and that the peculiar manner in which the nut of the Cocoa Palm has been observed to vegetate will be found to obtain in all plants having only one seminal leaf. How far this may be the case in the vegetables of the orders of Palm, Filices, and other monocotyledonous plants of foreign climates, I cannot pretend to say; in our own country, wheat, and other species of corn, having all seeds with one cotyledon, exhibit no extraordinary mode of germination; and that they observe the same laws in this particular as the dicotyledonous plants, with the difference only of the embryon breaking through the single lobe instead of being developed by the separation of the two seminal leaves, may be seen by taking out of the ground a few grains of wheat, or other corn, as soon as the young plant begins to vegetate.

In wheat, the cotyledon, or farinaceous part of the seed, becomes converted into a sweet pulpy juice, resembling milk, as soon

as the germ begins to sprout; and is gradually absorbed by the young shoot, leaving the withered husk to perish in the ground. In the two-lobed seeds, as Beans, Peas, and the kernels of Nuts, the nutritive store laid up for the support of the nascent bud undergoes no visible change in the consistency of the material, although after the commencement of germination it becomes sweeter to the taste, and in the progress it is wholly absorbed by the embryon vegetable, the outer coat of the seed only remaining. The better to elucidate this interesting subject, and to lay before my readers objects of comparison with the singular process of the Cocoa Palm in the evolution of the rising plume, drawings of the different modes of germination are annexed, both in the monocotyledonous and dicotyledonous vegetables.

In Wheat and Oats, and probably in all those seeds of the tribe termed Cerealia, two sets of fibres are protruded, distinguished by the name of seminal and coronal roots, the germ of Oat pro-

ceeding from the inside of the grain, that of Wheat from the external part. The seminal roots are the fibrils immediately shot forth from the seed-lobe at the time that the seed first vegetates; the coronal roots are protruded afterwards from the base of the newly-formed bud, analogous to what happens in all other buds; and from every joint in contact with the earth, root-fibres are freely sent forth; these seminal and coronal roots of Corn curiously resembling the supposed duplicate of vessels by which the buds of trees receive their nutriment; first, those formed to convey the saccharine juices, believed to be prepared for the sustenance of the bud in its first stage of germination, analogous to the tubular cord through which the milky pulp of the grain of Wheat passes to the growing germ; and, secondly, the root-fibres ready to be protruded by the leaf-buds after their expansion, similar to the fibrils thrown out at the base of the newly-opened buds of Wheat. The seminal and coronal roots

are separated by a fine tubular cord, consisting, probably, of very minute vessels, the length of which seems to depend on the depth of soil in which the grain happens to germinate. (See Plates 1, 2, 3, 4.)

If the annexed drawings are attentively studied, they will give the young physiologist a competent idea of the general mode of germination which takes place in the monocotyledonous seeds of Corn, and those of the dicotyledonous vegetables of the Nut tribe, and some other kinds; and will enable him to judge of that extraordinary deviation from the common course of nature, which is believed to occur in the evolution of the infant germ of the Cocoa Palm.

In the figure of a Walnut split into two divisions, given in the 4th Plate, he will observe, in one of the divisions, the diminutive germ lodged at the point of one of the portions of the cotyledon, or kernel; and if he will examine seeds of different species, he will, I believe, universally find, that al-

though the seminal lobes continue to increase in bulk, absorbing the pithy or farinaceous matter with which they are surrounded, until they have attained their full size, that the germ, after vivification, grows no more, until, with its cotyledons, it is planted in the soil; when the plume rises, the radicle descends, and the whole wonderful process of vegetation commences its course.

The 5th, 6th, and 7th Plates, at the end of the book, exhibit the phenomenon of the vegetation of the seed of the Cocoa Nut, in its different periods of growth, as far as I had it in my power to procure specimens of Nuts in their progress of germination. In the hope of gaining farther information respecting the extraordinary appearance of the Cocoa Nut, delineated in Plate the Fifth, I caused it to be planted in a hot-house; but probably the vegetating power was too much weakened previous to its being placed in soil to admit of advance of growth in either the radicles or plume, as those

parts decayed without any appearance of farther germination. Whoever may wish to make experiments on this interesting subject, should procure several Cocoa Nuts, which should be heaped together in the soil of a hot-house, and taken up and examined at different periods of their growth, and drawings made of the different states in which they may be found.

When the student has attentively considered the drawings of the Cocoa Nuts here given, he will observe that the kernel-like part, with which the shell is lined, and which is usually supposed to constitute the cotyledon, contrary to the general mode of growth in the seed-lobe or lobes of other plants, forms a capacious hollow, which is filled with a saccharine milky fluid, in vigorous trees reported to be in quantity frequently from a pint to a pint and a half. The seventh Plate will shew him the earliest progress of the infant germ, in its attempt to break through the strong integuments by

which it is apparently fast bound within the shell. And it is curious to observe the impression left on the inside of the hard husk of the nut by the tender leaves of this springing vegetable, as it forces its passage through that rugged substance. And for the purpose of remarking this wonderful effort, it would be well to plant two or three Cocoa Nuts, without separating them from their outer covering.—It can scarcely be doubted, that the small ball, found at the base of the newly-formed germ, increases in size as the embryon plant proceeds in growth; that it absorbs the liquid nutriment by which it is surrounded, and is itself absorbed by the growing plume; as after the rising plant has burst from the shell, and the tough fibrous case by which the shell is enclosed, and has thrown out root-fibres, this ball having acquired the full dimensions of all its parts, is found, with the hollow almond-like substance, in a state of decay. The plume and ball are visibly connected by a few threads, or

vessels; but it is difficult to discover by what means either of them can extract for their nutriment the cotyledonous lining of the shell, as both parts are apparently wholly detached from it.

Having shewn the general manner in which seeds vegetate, and that whereby the young plant usually derives its nutriment from the seminal leaf or leaves, with the peculiarity which in these particulars occurs in the breaking forth of the sprout of the seed of the Cocoa Palm, I proceed to the not less interesting subject, the annual renewal of bulbous plants; a process which will probably be found more similar to the re-production of buds in herbaceous and arborescent vegetables, than in the present imperfect state of knowledge in vegetable physiology may be supposed. That the materials of which the bulbs of Tulips are formed, are yearly absorbed by a young bulb rising from the caudex, or base, of that which gives it birth, is a fact which

has been known from, or before, the time of Grew; and which, from the circumstance of the change of position which takes place in the old and new bulb, relative to the flower-stem, could scarcely escape the eye of the most common observer. Every one must have seen, at the season of florescence, the flower stem of Tulip rising from the middle of the bulb; and any one who has had an opportunity of remarking the supposed same bulb when taken out of the ground, after the flower and leaves were decayed, must also have seen the withered flower-stalk lying on the outside of the bulb; and hence been led to the just conclusion, that this change of place must have arisen from the decomposition of that bulb, from the centre of which the flower had proceeded, and the production of a fresh one, to which the same flower had become external. Although this fact has been long known, the progress of it is yet little understood; and the knowledge of the re-production of bulbs so little extended, that the subject

will probably be nearly new to the generality of students of vegetable life. A few drawings, therefore, to elucidate this agreeable part of botanical science, will perhaps be acceptable to my young readers: and Plates 8, 9, will shew the progress of the renewal of various kinds of bulbs.

The flowering bulb of Tulip always produces another bulb, which bears a flower; and generally other large bulbs, which probably also flower; and numerous small ones, bearing leaves only: and so prolific is nature in all her works, that the large flowering bulb is no sooner formed than it begins, like the Polypus, to produce within its coats, or on its surface, very minute leaf-bulbs, which gradually increase in size, and the ensuing year fall off, and, after having gone through the successive renewals of several years, bring forth flower-buds. These small bulbs, arising from within the coats of the main bulb, should be farther investigated, and comparisons made between

their growth and that of bulbs raised from seeds, especially in respect to the time that each requires before it becomes capable of producing a flower. There is some difference, I believe, between leaf-bulbs and flower-bulbs in the manner of their re-production: the *leaf*-bulb is formed *within* the *leaf*-bulb of the preceding year; the flower-bulb, from its side. The variety of forms which the Tulip and other bulbs take, if impeded in their growth by want of room, or if the vigour of the main bulb is diminished by cold or rain, are worthy of observation; also that luxuriancy of vegetation, which sometimes produces bulbs on the flower stems of Tulip in the bosom of the leaves, is yet more deserving of remark. (See Plate 10.)

The peculiar circumstance of the Colchicum not ripening its seeds until the spring after their formation the preceding autumn, has given rise to an unwarranted opinion that the fruit is produced previous to the expansion of the flower, and which, from want of a little farther investigation,

has become an established popular belief. The re-production of the bulbs of this beautiful plant, which enamels our meadows after all other flowers have disappeared, and the extraordinary circumstance of the seed-vessel remaining so many months before it disperses its seeds, render its habits a subject of curiosity; and in the annexed plate drawings are given of the Colchicum at various stages of growth,—from autumn, the season when the flowers are in their prime; to spring, the time when the germ has arrived at maturity, and that the new bulbs are fully formed*. These bulbs take their rise from the caudex, at the base of the flower tube, and are united by communicating vessels to the old bulb, from the juices of which both the new bulbs and their flowers extract their nutriment. The same mode and process of growth in the young plants, and gradual decline of the parent bulb in consequence of having its juices absorbed by the in-

* See Plate 11.

creasing bulbs, occurs in all plants of the bulbous kind; as may be seen by opening Tulips, Harebells, Frittillarias, Dog-teeth, &c., at the period when their flowers are in perfection, and at other marked stages of their growth. In many species the rudiment of the future bulb is visible in winter; as may be seen by consulting the plates at the end of the volume.

Hence we perceive that bulbous roots of every species are governed by the same general laws in the re-production of both their viviparous and oviparous progeny, although the manner in which this wonderful process occurs is beautifully diversified in the different kinds of bulbs, of which specimens will be found in Plate 12.

In order to trace the Crocus-bulb from its first seminal growth, I sowed some seeds of the common Vernal Crocus, the germination of which is shewn in the Plate.

The long carrot-like fibre from the

Crocus-bulb is very generally found in all the species of that genus, and more peculiarly so in the Saffron Crocus. The bulbs of the common Gladiolus also throw out similar processes, which, with the root-fibres, drop off soon after the new bulb has attained its full growth. With the use of this apparent root I am not acquainted: it seems, however, more peculiarly to belong to those bulbs which have not arrived at the age of producing flowers, as I have more frequently remarked this appearance in leaf-bulbs than in flower-bulbs.

That I might observe the effect which the leaf might have upon the growth of the seedling bulbs of Crocus, I took twelve of them, the third year from the period of their germination, and planted them in a garden-pot in August 1793. In June 1794, when taken out of the pot, I found they had increased more than double, the number being twenty-seven. In another pot, time and all circumstances the same, I planted twelve others, and cut off

the leaves as they appeared above the soil, but not quite so assiduously as ought to have been done: the effect of depriving the bulbs of their leaves, was diminution of both size and quantity; the size of each bulb that had been robbed of its leaf being at least two-thirds smaller than those which had remained in their natural state; and in respect to quantity, six or seven small bulbs were the entire produce from the twelve which had been planted; half of that number, probably, having perished in consequence of the loss of their leaves. Eight of the healthy bulbs were planted again the autumn after their formation; and in April 1795 were again taken out of the ground. The produce was small, both in size and quantity; and having been exposed to much wet and frost, I supposed the bulbs which were planted to have been injured. The extraordinary figures of the bulbs in Plate 12, will shew the curious anomalies in vegetation occasioned by unfavourable weather and other adverse circumstances.

—I pursued my observations upon Crocus-bulbs no farther, but hope they may serve as a foundation for more extended experiments, by some ingenious students in the science of botany, to whom I offer the result of my researches as forming rather a sketch of that which may be discovered, than of any thing that has yet been thoroughly investigated; not, however, without flattering myself that my experiments may prove a base on which may be raised a valuable superstructure.

The Potatoe affords us another mode of fulfilling the general law of nature in the renewal of its species in the production of its viviparous progeny. This most useful vegetable is of the kind termed tuberous; the essential difference betwixt which and the bulb is said to be, that the buds are formed only on the surface. This, however, does not distinguish the tuberous from all the varieties of those roots which are usually known under the name of bulbous, as Crócus, Cólchicum, and Gladíolus. This is a sub-

ject by no means thoroughly understood, but which a few years will probably elucidate in a more satisfactory manner. With the systematical part of botanical science, we have at present little concern: the more pleasing one, the physiological history of roots, is that which must engage our attention. The Potatoe, notwithstanding it may be met with in every situation, is known to few in its habits and mode of propagation; and there are various species of exotics which would present to the generality of botanists a less novel spectacle than the delineation of a Potatoe-plant, at Plate 13, will probably exhibit. The Potatoe-bulb is thickly beset with small buds, every one of which is capable of becoming a complete plant; which, while attached to the old Potatoe, puts forth foliage and the parts of fructification, protrudes root-fibres, and throws out those shoots on which the young Potatoe is formed; the parent plant, like all other bulbous plants, being absorbed by the growing progeny to which it has given

birth, of both the viviparous and oviparous kinds. The young bulbs, although commonly known under the name of roots, are parts perfectly distinct from the radicles through which the nutritious juices of the earth are conveyed, and seem analogous to the stem-bulbs of Polygonum Viviparum, and others of that nature; as these bulbs, or young Potatoes, are not only produced from parts beneath the soil, but in some instances have been known to issue from every joint of the stems which made their growth above ground, and which at the same time produced at their summits all the parts of fructification *.

An experiment, which I made upon a small scale, nearly twenty years ago, evinced, that, by destroying the blossoms of the Potatoe plant, an increase of at least one-third in the bulbs might be obtained. Mr. Andrew Knight, who in his ingenious researches never loses sight of practical utility, by management di-

* See Darwin's Phytologia, section xvii. page 475.

rectly the reverse, procured seed from the early species of Potatoe, which under the common management rarely produces flowers. Mr. Knight caused strong stakes to be fixed in the ground, and mould to be raised in a heap round the bases of them, and in contact with the stakes. On their south sides he planted the Potatoes from which he wished to obtain seeds. When the young plants were about four inches high, they were secured to the stakes by shreds and nails, and the mould then washed away, by a strong current of water, from the bases of their stems; so that the real roots, or fibres, only entered the soil. Under this treatment Mr. Knight found that blossoms soon appeared, and that almost every blossom afforded fruit and seeds.

Farther ingenious experiments and remarks, by Mr. Knight, on the growth and culture of the Potatoe, may be seen in various papers published by the Horticultural Society, which are well worthy

the attention of the vegetable physiologist.

There have been doubts maintained of the advantage derived to the young plant from the superior size of the tuberous bulb from whence it springs; and it has been asserted, that the green tops of Potatoes, separated in June from the old plant, and set in the earth, have produced a good crop: and I have been assured by some gardeners, that they have practised this method with success. Also I have been informed, that in some counties a plentiful supply of Potatoes is obtained by planting the peelings only. It is difficult, however, to believe that the embryon vegetable can maintain its life and vigour when almost wholly deprived of the farinaceous substance of the cotyledon. Experiments on this point would be easy to make; and as nature usually provides a more ample store of nutriment for the beings which she brings into existence than will be necessary for their

sustenance, this superfluity, calculated to meet all casual circumstances, might probably in a great degree be spared from the actual well-doing of the embryon vegetable, and converted to farther useful purposes. On which principle the inferior Seed-corn, recommended by Sir Joseph Banks*, may produce a harvest as plentiful as the finest grain: and as in Potatoes the young plant throws out numerous root-fibres, even before the expansion of the leaves, it may require less quantity of the farinaceous part of the cotyledon to maintain it in vigour until that period of mature growth when it can fully provide for its own sustenance. Yet that a large portion of the nutritious juices of the parent plant are necessary to the support and health of the infant bud, is seen in those Potatoes which are infested by the disease called the curl, the stems of which are always found shrunk and shrivelled,

* Pamphlet on the Use of small Grain for Seed.

and the bulbs produced from them small and few; and the plant from which they spring remains in the ground hard and undissolved, or, in other words, not absorbed by the growing Potatoes: whereas in healthy plants the portion set in the earth, from which the young plants derive their origin, affords them sustenance by its juices; and as the infant progeny gradually increase in size, so the parent bulb gradually declines, until the whole of it finally disappears.

In support of the position of Sir Joseph Banks, that the seed of Wheat which, from the circumstance of unfavourable seasons, or from other causes, has not arrived at its wonted size, is capable of producing a full and vigorous crop of grain, we have the practice of experienced gardeners in their management of the seeds of Melons and Cucumbers; which they prefer at the age of two, three, or four years, to those taken fresh from the plant; as they believe that the superfluity of nu-

triment generally laid up in the cotyledons, by causing the herb to be more luxuriant, lessens the quantity of the grain; and that, by keeping the seeds some years, although they preserve their power of germinating, the farinaceous part of the cotyledons in some degree loses its nutritive property. And in fruit trees, and other vegetables, we find that whatever diminishes the excess of growth in the foliage, increases the product of the fruit. This subject is peculiarly interesting, as forming the basis of the most useful art of gardening;—an art, it is to be lamented, not yet accurately understood; and to the improvement of which, and of the still more beneficial art of agriculture, all speculative inquiry should tend. I shall be happy if this imperfect sketch of the physiology of vegetable life may in any degree be found assistant to my young readers in their study of this useful and interesting branch of science, and earnestly recommend to their atten-

tion, that experiments the most ingeniously instituted will be of no value, unless they lead to knowledge which is capable of being reduced to practical utility.